SOCIAL RESPONSIBILITY IN THE MODERN WORLD

RECENT presidential addresses to the British Association have frequently considered the impact of science on society—generally an aspect of that impact which the president could discuss with special authority—and have sought to indicate to the layman some implications of the advance in knowledge and technique for the world to-day. That responsibility is frankly accepted by this year's president. Dr. E. D. Adrian, whose address is printed on p. 433, believes that the Association should show the layman where the scientific age is leading him and that the success of the Association's meetings is to be judged by its impact on public opinion.

The theme of Dr. Adrian's address, however, is not so much the impact of science on society, as its impact on man himself. To appreciate the difference it is unnecessary to look back so far as Dr. Adrian himself did, to the famous meeting of 1860 which, as he pointed out, emphasized both that man himself is part of the physical world and also man's determination to go on searching for truth—a determination which has been sternly challenged even in the West during the past twenty years. We need look no further than the meeting at Oxford just sixty years ago. At that meeting, at which, in his presidential address, the Marquis of Salisbury referred particularly to our ignorance of the nature of atomic structure, of the ether, and of the causes and origins of life, Sir Oliver Lodge gave the first public demonstration of wireless signalling by means of electromagnetic waves, and Lord Rayleigh and Prof. William Ramsay gave a preliminary account of a new gaseous constituent of the atmosphere. The isolation of argon and helium and the other rare gases still lay in the future, with Becquerel's discovery of radioactivity. Even when next the Association met at Oxford in 1926, although Rutherford had indicated the possibility of atomic fission at a price, the discovery of the neutron lay half a dozen years ahead. Atomic physics and radiochemistry were still to develop, and even broadcasting was a relative novelty which had yet to exert its full power over the mind and habits of society.

On any comparison of the impact of scientific discovery and its applications on society between the meetings of the Association at Oxford in 1894 and 1926, and between that of 1926 and the present, the changes in habit, in opportunities for good and for ill have been far more profound in the second period. As Dr. Adrian pointed out, in atomic physics we face discoveries which could be used to devastate half the world, and if so applied would at least make life in the other half extremely precarious. Moreover, the direct effects of atomic explosions, though of chief concern to the strategist, are not the only dangers: repeated atomic explosions might lead to a degree of general radioactivity which no one can tolerate or escape. The dangers of contamination associated with the supply of atomic energy for industrial use can be avoided by suitable precautions; but in a major war such precautions would soon be set aside, if indeed they could be organized effectively. Dr. Adrian is almost certainly right in suggesting that a long war between powers well armed with atomic bombs would involve an order of radioactive contamination which neither victors nor vanquished could escape.

This additional risk of catastrophe does not, he argued, make our predicament much worse than that of earlier generations. Our predicament is the inevitable result of our curiosity and of the physical nature of the world in which we live; but if we can make our behaviour worthy of our increased knowledge, we can live safely. In other words, scientific advance has imposed on man the need for standards of conduct and forms of social organization which are appropriate for the new powers which are put into man's hands and the changed conditions under which he has to live. If man is to use wisely and safely the immense powers now at his command, he must accept the discipline that such use demands and adapt himself and his institutions accordingly.

Advances in atomic physics are not the only advances in science which make such demands on man. Advances in medical science can be misapplied, and drugs can be used for subduing men's minds as well as for the relief of pain and the cure of disease. Prof. A. V. Hill two years ago pointed to some of the implications of the eradication of disease in the way of social discipline for the backward areas of the world; and, as Dr. Adrian reminds his audience this year, a drug or a system of education which would make us all do as we are told, a method of producing radical conversion to a new system of belief or a knowledge of new ways of rousing patriotic ardour, could all be used with consequences as grim as the genetical deterioration in a radioactive world. The psychiatrist who discovers a cure for paranoia may find he has also revealed a convenient way of producing it.

How precarious is the division between the beneficial and harmful effects of any particular discovery has been emphasized by Mr. Charles Morgan and other modern novelists; and it cannot be too firmly insisted that if we continue to tolerate war, there is no kind of scientific investigation which might not be used for making war more destructive, no discovery in the field of human conduct which could be guaranteed harmless. The alternative to social discipline is, in fact, the renunciation of the whole process of discovery and investigation. To rely on increased knowledge for defence as well as attack is more likely to postpone than avert catastrophe, and the core of Dr. Adrian's address lies in his plea for the individual and social readjustment which these grave possibilities demand as a condition of the continuance of civilization.

The scientist, said Dr. Adrian, has a dual responsibility. He must apply his science to learn as much as possible about the mental and physical causes of our behaviour, and he must study human nature to

prevent its failures. He cannot, however, wait; for the discoveries might make us act more wisely. He must take men and women as they are, and make it his task at meetings like those of the British Association to point out that the human race cannot survive more than a few thousand large atomic explosions whether they hit or miss their targets.

If the British Association could make this known universally, Dr. Adrian believes it would have justified its existence, and to do so may just come within its declared purposes: "to give a stronger and more systematic direction of inquiry" or "to obtain a more general attention to the objects of science and a removal of any disadvantages of a public kind which impede its progress". He is less confident that a fuller understanding of the physiology of the brain or use of the means at our disposal to ensure clear heads or even tempers after a period of strain or fatigue would assist materially our efforts to live peacefully. Such means may diminish friction and misunderstanding, but we must find out what human behaviour is like before we try to explain how it is produced; and Dr. Adrian's address is an impressive plea for the many branches of social science to provide a dispassionate study of what actually happens in our society. In our pattern of human behaviour the units are men and women, rather than cells or molecules, on one hand, or on the other hand the large groups, with which it is often far easier to deal. When all allowance is made for the differences between the units, the general principles which determine their behaviour should stand out the more clearly because we are dealing with millions and not only individuals. With the increased knowledge psychologists now possess of the irrational factors which can sway the smaller groups as well as the family and the individual, Dr. Adrian believes the stage is set for what might well be the most important scientific development of this century.

Scientists and laymen alike may be growing more aware of the value of social investigation and of the degree of certainty it could bring; but they are scarcely as yet convinced that the kind of observation that the social scientist can make is really objective and precise. Few are ready, as Dr. Adrian remarks, to believe that the social scientists are more open-minded than themselves, and that they are capable of the open-mindedness and an almost superhuman power of selection which the nature of their material demands—of seeing the wood as well as the trees in it. Recognition of the difficulty of controlled experiments encourages reluctance to act on the findings of social scientists even when we can see that there are facts to be ascertained about our relations to one another, our usefulness in society and about the risks we take, and that the search for these facts could be conducted on reasonably scientific lines.

While therefore the social scientist deserves more generous support and a fitting place in the full stream of academic life, we should not expect too much. We may well find out a great deal about the tensions which lead to war without seeing how to eliminate war. Nevertheless, biological studies warrant the suggestion that human beings are not to be thought of as incapable of improvement. Alone in the animal kingdom, we possess a nervous system which enables us to order our ideas in words, and a way of thought which allows us to compare a new problem with an old; and our increasing background of experience makes Dr. Adrian confident that we are constantly acquiring new habits and new ways of thought. Our brains must have been so modified by what we have learnt that they are physically and chemically different, and better adapted for the complex social life of our time. We have more knowledge at our disposal, and if all goes well with our training, our brains should be more civilized than those of our fathers, and those of the next generation more civilized than ours.

It may well be that the scientific investigation of mankind can help the process of civilization by determining the weak points in our equipment and suggesting remedies, though such scientific activities may play only a limited part in the development of human society in this scientific age. The power we have acquired over the forces of Nature may indeed permit us to increase our mental training as well as our standard of comfort; but it does not follow that in many parts of the world the university, as we know it, will play the part in civilizing the most intelligent citizens that Dr. Adrian predicts. The university could not, admittedly, have opened its doors and extended its influence without the very inventions that have been blamed for our troubles—cheap printing and improved means of communication and transport. Whether the university is to be a fully effective civilizing influence depends on two factors: the threat to intellectual freedom, and our sense of social responsibility and self-discipline.

The control over Nature which science has given us has enabled us to improve our natures by more education in the arts of civilized living, and we may be able to do so more rapidly if we extend our insight into human behaviour and if we know where we are going. But we can no longer take it for granted that the British Association and other bodies will be able to foster this and every type of inquiry. Although it is human nature to inquire, to learn by experience, and to profit by what it finds out, that instinct, that right of inquiry, is threatened to an extent unknown since the Association was founded. Not only in Germany, in Italy, in Japan, in the U.S.S.R., in China, but even in the United States, man's right to knowledge and freedom of investigation have been challenged to an extent which made, for example, Columbia University centre its bicentennial celebrations around the theme "Man's Right of Knowledge and the Free Use thereof".

That threat cannot safely be disregarded while we seek to foster investigations which may indicate more precisely exactly how such anti-scientific forces arise and just how it is the values and ethics of science and of scholarship generally come to be repudiated. By and large, mankind knows why those values and that ethic are sometimes repudiated. It is not fresh knowledge that will enable mankind to restore

generally the conditions in which creative work flourishes, and solutions for the problems of mankind are sought with uninhibited, vigorous and imaginative minds: it is moral courage to act with wisdom and responsibility on what we already know.

No survey of the horizons which man's mind has yet to explore, and no plea for freedom of investigation and for clear unhampered communication of ideas, is adequate which takes no account of this need for wisdom and responsibility. "We have," said Sir Charles Sherrington, in his Gifford Lectures on "Man on His Nature" (p. 404; Cambridge University Press, 1940), "because human, an inalienable prerogative of responsibility which we cannot devolve, no, not as once was thought, even upon the stars. We can share it only with each other." Dr. Adrian mentions such social responsibility; but he does not drive home the real sharpness of the threat in anti-scientific and cultural trends to-day, or the challenge to individual as well as to social responsibility.

Every generation of mankind has to re-make its culture and its values and to re-adapt its institutions to the demands of changing circumstances and in the light of new knowledge; the tempo of change in our generation is such that our intellectual, social and political processes increasingly fail to keep abreast of contemporary needs. Hence there are strains and difficulties not only for institutions and the body politic, but also for the individual. It is in part, of course, a problem of communication, of assisting the individuals who make up the mass of society to understand what is happening under the impact of science, of integrating scientific thought and tradition into the rest of the general culture of our time. Only by so doing can we prepare men and women for the discipline demanded in an age of atomic power, broadcasting, television, aviation and the new powers of controlling disease, and leave them no longer bewildered by natural forces they do not comprehend, victims of ignorance, superstition and fear.

We can accordingly only draw comfort from the belief that new techniques and the growth of higher education will make successive generations more civilized if scientists address themselves seriously both to the task of exposition and interpretation, and to that of studying the limitations of our existing intellectual tools and frames of thought and their adequacy for the relations and conditions of to-day. As Dr. P. W. Bridgman has pointed out, we have to examine such social concepts as human rights, duties and responsibilities in the light of the environment with which technological change has surrounded them, and to revise if need be the conceptual foundation of our social and political system in the light of such an examination. In particular, we must have regard to the imperfection with which social organization functions in large communities, where the individual is liable to lose the sense of community and responsibility, and where what were virtues in a small community may even be inverted.

Dr. Bridgman may well be right to suggest that any such appraisal will result in a society in which relations between the individual and society rest on virtues comparatively unfamiliar. What is even more important, however, is that the process of human improvement which he and Dr. Adrian visualize does not rest solely on the furtherance of scientific inquiry into problems of human or civil biology, the physiology of the brain, human behaviour and social, industrial or economic relations. It rests equally on the co-operation and understanding of the ordinary citizen—on the sharing with him of the responsibility of which Sherrington spoke—and working out with him the changes and adaptations required to avert the grave dangers to which mankind is exposed and strengthen the control which at present we exert. Whether the future is regarded with pessimism or with optimism, however, depends less on the ability of men and women to adapt themselves to new circumstances or on the number of those trained to cope scientifically with their environment, than on the capacity of men and women to exercise the self-discipline demanded. It also depends on the wisdom and imagination which informs their political and social decisions, and on the emergence of standards of conduct, ideals, traditions and values and a view of life no less noble than those that inspired our forefathers and enabled them to hand on to us so rich a cultural and spiritual heritage, in which science itself is one of the great human endeavours and experiences.

THOMAS JEFFERSON, UNITED STATES PRESIDENT AND FARMER

Thomas Jefferson's Farm Book, with Commentary and Relevant Extracts from Other Writings

Edited by Edwin Morris Betts. (Memoirs of the American Philosophical Society, Volume 35.) Pp. xxiii+178+552+8 plates. (Published for the American Philosophical Society.) (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1953.) 15 dollars; 120*s*. net.

IT is a remarkable fact that two of the great founders of the United States were not only busy statesmen but also large farmers deeply interested in improving their land and in raising the standards of their own and their neighbours' agriculture. It is gratifying to us in these islands to recall that it was to Britain that they looked for the models on which to work, and which they were able to modify successfully to suit their local conditions. British students of agricultural history are familiar with the volume of letters written by George Washington to Arthur Young giving an account of his husbandry at Mount Vernon, Virginia, as well as more general information about the rural economy of other parts of the country: this was published in 1801, two years after his death. The American Philosophical Society has now given us a facsimile of the "Farm Book" of Thomas Jefferson, who lived at Monticello, near Charlottesville, Virginia, about 125 miles south-west from Washington, D.C., and who, like other Virginians of the time, increased his estates until finally they extended to some ten thousand acres. Much of his property was woodland; but several hundred acres were cleared and farmed:

the operations covered a wide range, for the estate had to be nearly self-supporting, providing not only most of the food but also clothes and shoes for the work-people and their families, nails for the carpenters, and other necessities.

Thomas Jefferson was born in 1743, was educated at the College of William and Mary, Williamsburg, and began life as a lawyer; at the age of twenty-six he entered public life, continuing therein for some forty years. His father died while he was still a boy, leaving him five thousand acres; another five thousand came to him later from his wife's father, but he had to leave them in the hands of managers who were not particularly competent. On his return from France "a ten years abandonment of them to the ravages of overseers", he wrote in 1789, "has brought on them a degree of degradation far beyond what I expected". Only in intervals of his active public life—the longest was from 1793 to 1796—and after his retirement from the second term of his Presidency in 1809, did he have time for close supervision on his own land.

The "Farm Book" covers the period 1774–1826. It is more of a note-book than a systematic diary; but the editor, Mr. E. M. Betts, of the University of Virginia, has included a number of Jefferson's letters which throw a flood of light on the problems of estate management of those days.

The work was done by Negro slaves, of whom he had about two hundred; as they increased by birth any superfluous ones were sold: the sale of a man for £100, the purchase of a woman and two sons for £210 and the transfer of eleven for £550 are among the entries. They seem to have been well fed and well looked after; in principle, Jefferson favoured abolition; in practice, he recognized its impossibility. For their food they were provided with maize meal, wheat flour (which they preferred), pork (600 lb. a year for a man and his wife), molasses, fish and peas. The molasses had to be purchased, but keen watchfulness was necessary as considerable quantities of water were liable to be added in transit.

The cash crops were tobacco and wheat; for home consumption large quantities of maize were needed. In the early days, Jefferson's farm manager had concentrated on maize and tobacco, growing them in a two-year rotation. Little manure was used, and inevitably the productiveness of the soil suffered heavily. Following Washington, he recognized the need for a rotation of crops, including clover, on the Norfolk lines, and among others he tried a five-course: peas, wheat, maize, wheat, clover. He used farmyard manure and also gypsum, about which he became enthusiastic. Much of his animal manure was lost, however, because of forest grazing; to obviate this he designed "a moveable air cowshed, to be set up in the middle of the field which is to be dunged, and soil our cattle in that"—an anticipation of the modern milking bail. However, he recognized that manuring might be uneconomical: "we can buy an acre of new land cheaper than we can manure an old one", he wrote.

He began his public life in the firm belief that the country should be predominantly agricultural. Farmers were for him "the chosen people of God": persons "whose breasts he has made his peculiar deposit for substantial and genuine virtue"; indeed, the establishment and survival of democracy in his view depended on peopling the land with farmers. The workshops that supplied manufactured goods, and "the corrupt cities they bred", should remain in Europe, exporting their goods to America in exchange for tobacco. After the war with Britain, however, he favoured more self-sufficiency.

He had a flair for mechanical invention, and perhaps his best contribution to agriculture was his discovery of an exact formula for the construction of the mould board of a plough that would cause the minimum of friction in its passage through the soil. He experimented with sheep; he had many pigs—he kept a breeding sow for every two labourers—and he gives details of the amount of maize required to fatten a pig: one bushel, he said, will produce 10 lb. increase in weight: assuming the bushel weighed the usual 60 lb., the result is within about 10 per cent of the figure given by the much later Danish experiments.

Jefferson was not only a statesman and an advanced agriculturist, he was also a man of wide education; this, however, did not save him from the fate that has at times befallen other agricultural improvers: he kept open house for his visitors and was often in debt; he might have died a bankrupt but a public subscription was raised to make his position secure.

The book is sumptuously produced and is well worthy of its distinguished subject: it is a rich store of material for students of the agricultural history of that important period. The American Philosophical Society is to be congratulated on its enterprise in arranging for production of the book, and Mr. Betts for the prodigious labour and careful scholarship he has devoted to its preparation.

E. John Russell

MODERN CYTOLOGY

International Review of Cytology

Edited by G. H. Bourne and J. F. Danielli. Vol. 2. Pp. xii+545. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1953.) 11 dollars.

SYMPOSIA and volumes of reviews must at one time have been intended to spare scientists the burden of reading the original literature in fields of research lying a little to one side of their own; but they have long since become a literary incubus in their own right. This stricture applies far more to those reviews which are in reality mere bibliographic inventories than to articles of the style presented here. The present volume contains more than a dozen lengthy and carefully prepared reviews by recognized workers in the fields of cytology, cytochemistry and microbiology. It is admirably got up—as indeed it should be, at the price.

First among the articles of non-sectarian interest is Hämmerling's admirably translated review of his work on *Acetabularia*—work which no biologist should admit to being ignorant of. At the other extreme, Conway's concentrated theoretical discussion of the redox pump will presumably have the smallest following, for most biologists admit, with uncalled-for complacency, to a total ignorance of thermodynamics. Between these extremes are a number of reviews of orthodox pattern: cytochemical findings are described, their validity inquired into, and their significance pondered upon. Gaillard's summary of a wide variety of researches into the behaviour of cells *in vitro* stands rather apart from this classification, and so does the article shared between Mudd and Sutcliffe on the cytology of bacterial cells. Both contain evidence that is not so compendiously presented elsewhere.

In limited space, only one of the several articles that deserves it can be called specially to the attention of specialists in other fields: that in which H. R. Mahler writes on those complex many-stage enzymic reactions which remain functionally in gear in cell-free extracts containing mitochondria and smaller particles. The *kind* of system that gives functional coherence to the metabolic activities of the cytoplasm is slowly beginning to appear, and it seems to be particulate rather than, in the ordinary sense, 'skeletal'. Indeed, the cytoskeleton seems to have a rather ether-like status: one feels that something of the kind should be there, but more than one observation (for example, on ultracentrifugation) that could rank as an *experimentum crucis* can be reconciled to its non-existence. Now that complex reaction sequences appear to have an anatomical as well as a functional unity, it might be argued that the whole concept of 'separate' enzymes has no place inside the cell, however well it has done duty by the perhaps highly specialized and unrepresentative enzymes that are secreted by cells and work outside them. The argument is tempting, but it will not do. 'Separateness' does not stand or fall by separability, and the enzymes of complex many-stage reactions could be identified by specific inhibitors and substrate competences (or, in micro-organisms, by the skilful use of gene mutations) even if not one of them had been isolated. As it happens, many have been; but what is important about these complex reactions is not their divisibility but their actual indivision, and the biologist will be satisfied to learn of the existence of a level of integration that is so much larger than the molecule and so much smaller than the cell.

P. B. MEDAWAR

SENSORY GATEWAY TO THE MIND

The Human Senses

By Prof. Frank A. Geldard. (Wiley Publication in Psychology.) Pp. x+365. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1953.) 40*s*. net.

THE study of the human senses has long been and still remains among the most rewarding fields of psychological inquiry. More than a third of Stevens's "Handbook of Experimental Psychology" is devoted to it. A book exclusively occupied with the subject is therefore to be welcomed. The present effort covers partly the same ground as Piéron's "The Sensations", the English version of which appeared in 1952, though in mastery of the subject it scarcely bears comparison with its distinguished predecessor.

The usefulness of Prof. Geldard's book lies chiefly in its careful review of the recent literature on those aspects of the subject in which he is primarily interested, and those aspects are at least as much physiological as psychological. His own publications include papers on visual phenomena, retinal fatigue and brightness contrast, and on somesthesis. He has also made an exhaustive study of the so-called vibratory sense, arriving at the conclusion that it is not a separate sense but simply 'pressure in movement'. But he is equally at home in the chapters on hearing, temperature and labyrinthine sensitivity, kinæsthesis, smell and taste, though he makes little attempt at synthesis or critical evaluation of rival theories.

Prof. Geldard has not confined himself to American sources. The omission of any reference to the researches of Piéron, doyen of sensory psychophysiology, is all the more noticeable. Nor does the chapter on "The Skin and its Simuli" leave the reader with any glimmering of the haptic qualities of the hand as studied by Révész or Katz.

At one brief stage, in the chapter on colour vision, the author decides to drop the psychophysiological approach and assume a phenomenal viewpoint. It is a pity he did not sustain this second viewpoint throughout. He might then have found it unnecessary "to sidestep the vexing problem of form perception". He might also have found it possible to give more adequate consideration to the problem of pain; no part of the book reveals the limitations of a purely psychophysiological approach more sharply than the discussion of pain. Conceivably he might also have been led to see the importance of intermodal phenomena in sense perception.

Prof. Geldard's initial manifesto raises our expectations. "The highroad to the understanding of human nature," he declares, "is by way of an appreciation of man's senses and of the fundamental role they play in the attainment of knowledge and the regulation of behaviour." This may be the case; but we shall never convince anyone that it is unless we extend our interests to the personal and social aspects of sense perception. Prof. Geldard's inclinations do not seem to reach so far. He does not seem to share the view that the psychologist's task is not to concern himself with eyes, ears and skin as such but with a person seeing, hearing, touching. His restriction of interest is scarcely calculated to lead the reader on the "highroad to the understanding of human behaviour".

JOHN COHEN

THE PRACTICE OF FORESTRY

Forestry

By Prof. H. G. Champion. (The Home University Library of Modern Knowledge, No. 226.) Pp. vi+230. (London: Oxford University Press, 1954.) 6*s*. net.

THERE has been a long-standing need for a simple survey of what is meant by forestry. It is, of course, difficult to write an outline of any large subject, and the method of approach depends partly on the background of the author. Prof. Champion spent a considerable part of his professional life in India, and he has travelled widely in other parts of the world, both tropical and temperate. He has accordingly drawn his illustrations from a wide field. This is the distinctive quality of the book, and it adds greatly to its interest.

The book is comprehensive and the reader may rest assured that he has got at least a glimpse of every facet of the subject. The first chapter deals with "Forests and Trees", and brings together varied information from all over the world: the oldest trees, the tallest trees, the greatest girths, as well as short discussions on all aspects of the life-history of trees from light requirements and pollination to mycorrhiza. This is one of the most interesting chapters in the book. The second chapter, entitled "Structure of Forests", presents the forest as a plant community, discussing not only its structure in an ecological sense, but also the effect of competition, certain aspects of succession, the classification of forests on climate, and the ecological influences of man on the forest. Again, the illustrations are drawn from a world background. Chapter 3 discusses

briefly the varied products from the forest, not only timber as such and as a source of cellulose, but also bamboos, fibres, gums, resins, medicines, fodder, etc. Then follows a brief but interesting discussion of the history of forest clearance to provide agricultural land, for timber products, and for hygienic purposes, such as an anti-malarial measure and for tsetse control.

Under the title of "Forest Influences" the author outlines the effect of forests on rainfall, water regime including erosion, wind and temperature, as well as a brief reference to the forest as a habitat of animal and plant life. The chapter on "Forest Conservation and Protection" discusses fire protection, control of grazing and protection against animals, insects and fungi, as well as natural agencies such as wind. The next chapter outlines methods of surveying forest resources, methods of extraction of timber, and the preparation of products from sawn timber and pulpwood to wood distillation and resin derivatives. The next three chapters deal with sylvicultural techniques used in the natural and artificial regeneration of woods and their subsequent tending; generalities are spiced with sufficient detail to make them interesting. Under the title of "Growth of Crops", the techniques of the measurement and management of forests are discussed, while the chapter on "Reclamation and Afforestation" draws its examples from the Culbin Sands in Scotland to the papyrus swamps of Uganda. There is a short chapter on forest policy, law, research and education, while the last gives a brief picture of forestry in the United Kingdom.

In the concluding paragraph, the author considers that it is inevitable that there will be a further reduction in the area at present under forest in certain parts of the world, particularly the less developed, but that this loss will be made good, at least in part, by afforestation of land mistakenly cleared of forest and also land not previously woodland, but which can now be made to carry trees by improved techniques, as in Great Britain, and also by improved production per acre. He has no doubt as to the future of wood as a major world raw material.

This book worthily upholds the reputation of the series for serious but non-technical exposition of a subject. It is remarkable for the amount and variety of the information that the author has presented so skilfully, concisely and lucidly. H. M. Steven

MONKEYS AS PETS

The Monkey Book

By Ernest P. Walker. Pp. xii+154. (New York: The Macmillan Company, 1954.) 6.50 dollars.

THIS book, by the assistant director of the National Zoological Park at the Smithsonian Institution, Washington, tells the owner or would-be owner of a pet monkey all that he should know. Mr. Walker has not only successfully supervised the keeping of monkeys in captivity for many years, but also has been answering questions on the subject for as long—now he has set forth his experience and knowledge in an attractive volume. The book will be of great value not only to private keepers of pets but also to those concerned with the care of monkeys in zoos and research laboratories.

The work is divided into two parts; the first part deals with general questions of animal management as applied to the primates, and is full of valuable information ranging from feeding, cages, exercise and health to psychology, and what to do when a pet escapes. This is excellent, and the chapter entitled "Psychology", pointing out that the psychological problem of keeping pets happy is of even more importance than the problem of supplying them with food, should be studied by everyone who keeps wild animals in captivity. A sub-section of the first part giving instructions for the maintenance of cultures of mealworms, wax moths and crickets as food for captive animals is particularly helpful.

The second part of the book deals systematically with all the more-or-less valid groups of species of living primates other than man, and a page is devoted to each of the genera recognized by the author, from lemurs and lorises to anthropoid apes. An introduction gives a short explanation of classification and then a brief description is given of representative species of each genus, with notes on distribution, habits and food, and advice on management in captivity, the probability of obtaining specimens from dealers, and the range of market prices. A special feature of the book is the excellent series of illustrations, mostly from photographs but some from drawings, that gives a splendid pictorial guide to the variety of forms throughout the primates.

The author believes that no pet, if properly treated, will give more satisfaction and companionship than a monkey. The instructions for the care of pet monkeys given in this book will enable owners to derive the maximum of enjoyment from their favourites and will prevent the premature loss of many animals.

The book concludes with a well-chosen select bibliography and a full index. It is a pity that its very high price, for a book of its type and size, will put it beyond the reach of many of those pet enthusiasts outside the United States who would benefit most from possessing it.

L. Harrison Matthews

COALFIELDS OF GREAT BRITAIN

The Coalfields of Great Britain

Edited by Sir Arthur Trueman. Pp. xi+396+7 plates. (London: Edward Arnold (Publishers), Ltd., 1954.) 63*s*. net.

THIS book is a welcome successor, well suited to present-day requirements, of Walcott Gibson's "Coal in Great Britain", the second edition of which appeared in 1927. During the intervening period, many striking advances have been made in the study of the Carboniferous coals and associated strata with which the present book is almost exclusively concerned. More especially, mention should be made of the palæontological results achieved by Sir Arthur Trueman and other well-known workers, and the detailed re-mapping of the coalfields by the geologists of the Geological Survey. Greater precision has been achieved in most branches of the subject, and many of its aspects have been revolutionized by discoveries of recent years, including, it may be added, those of the authors themselves. All this material, old and new, has been dealt with by Sir Arthur Trueman and his expert collaborators with commendable clarity, and also adequately. Indeed, an outstanding feature of the work is its well-balanced presentation of a subject so charged with detail as is coalfield geology. The two needs which the book aims to meet, those of the

geologist and the worker in coalfield industries, have been clearly kept in view, and both interests have been served without sacrifice of scientific method or of the requirements of the practical point of view. Perhaps a chapter dealing with the fossils of the Coal Measures and associated strata and their use as stratigraphical indicators may be fittingly singled out for mention. For it serves as an example of treatment of a highly technical subject in a manner in which the results can be appreciated and applied alike by the geologist and the mining engineer.

The chapter dealing with fossils forms one of a series of opening chapters written by Sir Arthur Trueman which comprise nearly a quarter of the volume. In these chapters, the essential points in regard to the geology of coal and the Coal Measures are described in an admirably simple and yet comprehensive way. The subject of coal as a rock is followed by a description of the rocks of the Coal Measures. Next, geological structures are dealt with; then fossils of the Coal Measures and their use; and lastly, the origin of the British coalfields.

Individual coalfields are next described in a series of eleven chapters. The main plan in each case is to supply a general introduction followed by accounts of the succession and structure, details of the stratigraphy and, finally, notes on coal reserves, references being appended to each account. Where required by individual writers of these chapters, additional features are included, such as the anthracites of South Wales, and the character of the coals in other cases; the history of development of the local mining industry; proved or possible extensions of a worked coalfield; and the occurrence of igneous rocks, especially in Scotland. Not only coal, but also other materials of economic importance such as bedded iron-ores and fireclays, are reviewed. In general, a variety of interests are served *pari passu* with more important objects.

A brief statement of the authors concerned and contents of these detailed chapters may be given. Prof. L. R. Moore deals with the South Wales coalfield, and with the coalfields of the Forest of Dean, Somerset and Glamorgan. The Kent coalfield and other possible concealed coalfields south of the English Midlands are treated by Dr. C. J. Stubblefield. The Yorkshire–Nottingham, Lancashire and North Staffordshire coalfields are described respectively by Mr. Wilfrid Edwards, Dr. F. M. Trotter and Prof. F. Wolverson Cope; those of North Wales by Prof. Alan Wood and of the South Midlands by Dr. G. H. Mitchell. Accounts of the Northumberland and Durham fields are given by Dr. W. Hopkins, and of Cumberland (mainly Whitehaven coalfield) by Dr. Trotter. Finally, the coalfields of Scotland are described by Dr. Murray Macgregor.

The book is adequately illustrated with a number of well-drawn maps, horizontal sections and comparative vertical sections of the local successions of coal-seams, together with drawings of representative and zonal fossils and photographs of plants. An index is supplied at the end of the volume. This fine work will undoubtedly be widely read and be closely scrutinized by the many workers concerned in the subject. It is one of great economic as well as scientific interest, and Sir Arthur Trueman and his co-authors are to be warmly congratulated on their achievement. In its pages a critic can find little for comment except to praise, and a reader, whether expert or student, will gain both pleasure and enlightenment.

J. E. Richey

ORGANIC CHEMISTRY IN THE ARTS AND MANUFACTURES

Industrial and Manufacturing Chemistry

By Geoffrey Martin. Part 1: Organic. Seventh edition, revised by Edward I. Cooke. Pp. xxi+752. (Kingston Hill: Technical Press, Ltd., 1952.) 90*s*. net.

BETWEEN the first and seventh editions of this book lies a period of forty years; indeed, a thirty-year interval separates the sixth edition and the present revised seventh, and during this period many branches of industrial chemistry have been completely revolutionized, while others, unknown forty years ago, have arisen, undergone development and reached an important place in the present-day industrial field. New chemical techniques and new methods of manufacturing old-established products have followed expansion in chemical knowledge, chemical engineering advances and metallurgical developments of the past forty years. But much of this finds no record in the present book.

The present editor, Mr. E. I. Cooke, faced with the stupendous task of dealing with the twenty-four sections into which this book is divided, has succeeded with his collaborators in completely rewriting some sections, dealing respectively with petroleum refining, manufacture of condensed milk and milk powders, the fatty acids industry, fuel gas industries and coal tar. Much has been done to improve the sections dealing with sugar, rubber and synthetic drugs: a former section on explosives has been omitted and replaced by one on the plastics industry, which unfortunately had to be curtailed due to considerations of space.

But a very large part of the book bears the stamp of the original edition; in most of the sections there are no references to original literature later than 1912 and, almost throughout, the statistical information given relates to the years around 1910–12 and is thus completely valueless. Also, this defect is not remedied by the very sketchy statistical information in Appendix 3. Much of the book, in fact, can be considered as little more than a historical review of the subject-matter to the stage it had reached some forty years ago; but from this point of view there is much to recommend the volume. Yet, if it is to continue to serve a useful purpose every section of it needs drastic treatment to bring it up to date—a task likely to involve its subdivision into two if not three volumes.

Extensive developments have taken place during the past few years in methods of extracting and refining fatty oils, in continuous hydrogenation and in the manufacture of margarine, now an important article of dietary throughout the Western world, though only four pages are here allotted to its consideration. The treatment of essential oils, perfumery materials and synthetics is quite inadequate. The term 'artificial silk' went out of use many years ago, being replaced by the word 'rayon', which finds no use, however, in the present volume, though the relevant section on the cellulose industry is generally well written. Similar remarks apply to the manufacture of alcohol and industrial solvents, where considerable development has occurred during the past thirty years so that we no longer strive to get methyl alcohol and acetone in commercial quantity by wood distillation.

The major technological change in the detergent industry, no longer based exclusively on soap, has brought new products and created new difficulties. The continuous soap-making process and continuous soap drying are revolutionizing the industry, causing thereby an immense saving in labour and steam. Changes such as these should have found mention in the relevant section.

Appendixes 1 and 2 and the two indexes appear to have been well done. The book is well produced and generally free from typographical errors.

H. M. Langton

A NEW PERIODIC TABLE

A New Periodic Table of the Elements Based on the Structure of the Atom

By Dr. S. I. Tomkeieff. Pp. 30+2 charts. (London: Chapman and Hall, Ltd., 1954.) 10*s*. net.

TO demonstrate the periodicity in the properties of the chemical elements, Lothar Meyer chose the most direct representation: he plotted the elements in the order of their atomic weights on the abscissa, and the values of the property in question on the ordinate. At the same time, Mendeléef published the Periodic Law in the form of tables; he had to decide whether the short or the long period were to be chosen for the length of the rows; but this was the only arbitrariness.

During the following decades innumerable attempts were made to improve on Meyer and Mendeléef. All sorts of representations, trees with branches, concentric circles, spirals, figure-eights, and various three-dimensioned curves—mostly drawn on the surface of cylinders and cones—were tried; behind all this was the hope to get nearer to the mystery of the periodic system if a more perfect arrangement could be found. But the scientific result of all these attempts was nil; an understanding of the periodic system could only be achieved on the basis of quantum mechanics.

It is somewhat astonishing to see that quite recently "A New Periodic Table of the Elements" has been published which is a revival of the old discarded attempts. The curves, for example, which represent the specific gravity of the elements, are based on one of the well-tried spirals and can, naturally, not avoid the old drawbacks: such elaborate curves are tedious to draw, provide no help to the memory, and do not contain any information which could not be included in simpler representations. How much more clearly does the periodicity of the specific gravity show up if plotted according to Lothar Meyer's straightforward method! The author recommends even a cone-shaped periodic chart, another repetition of previous suggestions; whoever takes the trouble to follow the advice to cut the drawing out and to gum it together as a cone, will scarcely get any insight into the sequence of chemical elements which the usual tables do not give.

It is not very obvious why the author calls his table "based on the Structure of the Atom". It is true that the introductory pages contain an elementary description of the shell structure of the atoms, but this text has no connexion with the graphic part of the publication. It is also doubtful if the "Table of Elements"—extending over fourteen lavishly printed pages—will be of great help to the readers. One of the columns describes the colour of the elements, necessarily with the frequent monotonous repetition of the descriptions "silvery white" or "iron-grey"; this column should make it clear that the main value of the periodic system is not based on the properties of the elements as 'simple bodies', but on the periodicity which they show in their compounds. It is also questionable if the information provided in the column "normal state of the element" is very instructive without giving more details; we are, for example, told that normally iodine is a metal.

Being a geologist, the author may have reason to suppose that some of his colleagues will find such a periodic table useful; but it is not certain that chemists or physicists or, for that matter, geologists who have sufficient knowledge of chemical and physical publications on the periodic system, will obtain much help from his book.

F. A. Paneth

THE STABILITY OF THE SUN

Dialogue Concerning the Two Chief World Systems—Ptolemaic and Copernican

By Galileo Galilei. Translated by Stillman Drake; foreword by Albert Einstein. Pp. xxvii+496. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1953.) 75*s*. net.

THOMAS SALUSBURY, in the address to the reader which prefaced his translation of the book now in question, wrote in 1661, ". . . that singular and unimitable Piece of Reason and Demonstration the Systeme of Galileo. The subject of it is a new and Noble part of Astronomy, to wit the Doctrine and Hypothesis of the Mobility of the Earth and the Stability of the Sun". This is a very just epitome of the famous *Dialogue*, in which the Ptolemaic system is held up to ridicule and the Copernican system abundantly justified. It is, perhaps, strange that nothing should be said of the Tychonic system, which had been elaborated by the greatest astronomical observer of the time, but there it is. Galileo was concerned with the Copernican system alone and did not even mention the fundamental discovery of the elliptic form of the planetary orbits, familiar as he was with Kepler's work and highly as he thought of it in general. Strange!

The dialogue is between three characters, Salviati and Sagredo, friends of Galileo distinguished by noble birth and keen intellect, and a third character denoted by the name Simplicio. Both Salviati and Sagredo were dead at the time when the book was written: into Salviati's mouth are put the words of Galileo himself, while Sagredo represents a witty and astute man versed in the general learning of his time. To him are given the most biting comments on the arguments of Simplicio, the peripatetic philosopher, while Salviati-Galileo, with his tongue in his cheek, remarks, for instance, "Sagredo, you are too caustic and sarcastic. Let us put all joking aside, for we are dealing with serious matters". It has been surmised that Simplicio was meant to represent Pope Urban VIII, but this is unlikely on several grounds. The Pope, Maffeo Barberini before his elevation, had been a friend and patron of Galileo and was certainly no extreme Aristotelian, and Galileo, although no

courtier, would scarcely have invited certain retribution by putting, as has been suggested, arguments supplied by the Pope into the mouth of a figure held up to ridicule. Galileo says that he has given "the good Peripatetic" the name because of his excessive affection towards the *Commentaries* which the neoplatonist Simplicius wrote on Aristotle. While it is not well to take everything that Galileo said in this book at its face value, there seems no reason why this should not be correct.

The *Dialogue*, while not equal to the *Discourses* as a record of original advance in the fundamentals of science, is of the greatest importance both for the immense effect that it had in winning support for the new scientific outlook and for its bearing on Galileo's personal history. The effectiveness of the arguments and ridicule brought to bear against the Ptolemaic system is widely acknowledged beyond the circle of those who have had recourse to the book. The way in which it shows the hold that certain of the older notions still had upon Galileo is less generally recognized—less still, probably, the actual errors which it reveals, particularly in the matters of the cause of the tides and the nature of comets, where Galileo was less correct than certain of his contemporaries. For all those interested in the great man's mind and in the conflicting currents of his period the book is of supreme significance, but hitherto the only English version has been the extremely rare one by Salusbury to which reference has been made.

This new translation, by Mr. Stillman Drake, is evidently a labour of love. In his excellent and modest preface the translator excuses his occasional departure from strict literalness by very properly saying that easy reading is the great requirement. He cites Galileo's dislike of pedantry : he might have quoted his predecessor Salusbury, who wrote "The Book being for Subject and Design intended chiefly for Gentlemen, I have bin as careless of using a studied Pedantry in my Style ; as careful in contriving a pleasant and beautiful Impression". To-day the style of Salusbury's conscientious work, even if it were generally available, would offer difficulties to most readers. The present translation achieves an admirable balance, avoiding on the one hand colloquialisms that would be inappropriate in a classic of this kind and on the other hand a rigid verbal adherence to the text that would be troublesome. It is couched in a simple and straightforward English that has, nevertheless, well preserved the character of the original and is furnished with excellent notes which give the reader just what help he is likely to require, without holding him up by too frequent interruption. In spite of, or perhaps because of, their brevity these notes demonstrate how well qualified the translator is for his task.

The book further boasts a preface by Einstein which will be read with the attention that anything from his pen deserves. This is printed in German on the left-hand pages, with an English translation opposite. This translation is dictionary-literal, with occasionally a droll effect, as when we are told that "Apart from its revolutionary factual content the *Dialogue* represents a downright roguish attempt . . .". The roguish Galileo, at sixty-six years old, is an appealing picture. But such things are trifles. The book, which is beautifully produced, is to be warmly welcomed as offering scholarly and substantial evidence of the growing interest in the classics which lie at the foundations of modern science.

E. N. DA C. ANDRADE

AUTOMATIC CONTROL FOR ECONOMIC SYSTEMS

The Mechanism of Economic Systems

An Approach to the Problem of Economic Stabilisation from the Point of View of Control-System Engineering. By Prof. Arnold Tustin. Pp. xi+161. (London : William Heinemann, Ltd., 1954.) 25*s.* net.

UPON the conventionally trained economist this book will have some of the effects of the sculpture of Reg Butler or Barbara Hepworth on those who admire the statues in our streets : "I can't get to grips with it" ; "I don't see the point of this extraordinary technique" ; "It's all wrong".

It is, I think, easy to see how this exceedingly unusual book came to be written. Prof. Tustin is a very eminent designer of the means whereby electrical mechanisms acquire 'self-control' of essentially the same sort as that given to a steam-engine by its centrifugal governor. Struck by the misery and danger which arise from the booms and slumps of orthodox economic systems, he plans to stabilize these systems by building into their essential structure some features inspired by control-system engineering and working by exactly the same formal principles. But this is not all. The discomfort caused to mathematicians by the work of Oliver Heaviside (whose name appears in the text but is omitted from the index) has in the past dozen or fifteen years very largely been removed by the translation of his methods and results into the language of the Laplace transform, by which the description of the behaviour of any variable as a function of time can be replaced by its description as the sum of a set of exponentially growing or diminishing sinusoids (and thus in effect as a function of frequency), and calculations concerning it thus brought within reach of the compact elegance of vector algebra. It is, I think, the beauty and power of these mathematical methods, almost as much as the urgency of the economic problem and the hope of solution inspired by the wonderful success, in its own sphere, of control-system engineering, which has driven Prof. Tustin to attempt the conversion of economists to his gospel.

To effect this conversion he has first to teach them his language, for few economists are expert in harmonic analysis or even in vector algebra. This education he attempts in a sympathetic, ingenious and optimistic chapter of some sixty-six pages and thirty diagrams, which the non-mathematical reader is urged to "read, at first, straight through, in a light-hearted and optimistic spirit, so as to get the broad idea". I do not deny that such a man, if his lack of mathematics is accidental and not inborn, will have his imagination caught by many a stray gleam from this rich river of ideas and may even feel himself carried along by its urgent enthusiasm of exposition. But to expect the average student of economics to wrestle with this chapter, let alone to master it and add it to his effective equipment of mental tools, is wildly over-sanguine. It is still true that mathematical aptitude does much more for a man in physics or engineering, where it is indispensable, than it does in economics, where formal mathematical procedures are rather like a pair of skis, contributing tremendously to one's speed in special favourable conditions but elsewhere useless. In consequence, economics departments have com-

paratively few mathematically capable students, attracting instead people of equal mental calibre but with a bent towards philosophy or history. For that small group of professional economists who are mathematicians by nature but not by training, Prof. Tustin's Chapter 3 will be invaluable. This chapter could, I think, in spite of the imaginative efforts which have been made to meet the uninstructed reader half-way, be considerably improved in detail. We read, for example, from p. 55 onwards, the expression "modes of free motion"; but this phrase is not defined until several pages later. Such points may seem insignificant; but they can be fatal to a reader's effort to follow an argument.

The great unproved assumption, on which Prof. Tustin's whole thesis and programme rest, is that an economic system can be treated as a machine which cannot hide in the heart of its nature and being any autonomous capacity for responding differently, to-morrow, to a given situation from its response at a similar situation to-day. It is not, that is to say, essentially impossible to know what the economy will do in given circumstances, and it is not essentially impossible to know the circumstances themselves through and through so that nothing which matters is hidden from us. It may be, for all I know, that this assumption will be confirmed. No experiment could have a more overwhelming claim on the interest of all economists, or indeed of philosophers in general, than to find out if Prof. Tustin is justified.

G. L. S. Shackle

FOOD AND POPULATION

The Limits of the Earth

By Fairfield Osborn. Pp. 175. (London: Faber and Faber, Ltd., 1954.) 12*s*. 6*d*. net.

THE author of "Our Plundered Planet", which succeeded in bringing to a large section of the American public some idea of the current profligate use of natural resources, now presents primarily to the same audience a broad picture of increasing population pressure on world food output. He does not attempt, as the title of the book might suggest, either a definition or a delimitation of the *oecumene* or habitable area of the globe, but passes in review, based on such statistics as are available, through the principal regions. Accepting a world population increase of 75,000 a day, he assesses their ability to meet the food needs of the increase.

Australia, New Zealand, Canada and Argentina are considered as the four main 'food surplus' countries, but where nationalism, rightly condemned industrialization and urbanization all threaten the home food supply and deprive the world of badly needed food surpluses. The Amazon is regarded with a certain cautious optimism; but tropical Africa, whatever its future line of development, can help the world position but little because the "African will take the land for his own". South Africa is regarded as the supreme example of the forces of science and technology frustrated by social and political conditions. The chapter on the United States underlines the author's insistence that the resources of the erstwhile "land of boundless resources" are in fact strictly limited.

The regional treatment is popular rather than profound, and least satisfactory is the chapter on Europe, where the economic position is naïvely oversimplified to fit some of the author's preconceived theories: thus, "when petroleum came into general use, the coal of England and Wales began to lose its high premium value. The strength of England's economic structure simultaneously began to diminish"; Holland has lost the East Indies, and Sweden is pioneering in new ways of population control untrammelled by religious dogma and therefore "contrasts in the ways of life of peoples living in close proximity could not be more vividly exemplified than by comparing the situation of Holland with that of Sweden" (p. 27).

A chapter on "Horizons and Mirages", devoted to additional resources, touches briefly on possibilities of increasing fisheries, using plankton, seaweeds and pond culture, and technical developments in agriculture such as soil conditioners and synthesis of proteins. On the other hand, certain obvious developments really within our grasp the author seems content to ignore. He appears satisfied, for example, with low American acre-yields needing three acres of improved farm land to support one person (against one acre over much of Europe) and quotes the U.S.S.R. with its far greater climatic handicaps as about the same standard in land requirements *per capita*. The stultifying effect of tariffs and other international trade barriers does not get a mention: the assumption seems to be that each political unit must support its own population from its own home food resources. A special word of praise is due to the publishers for continuing to bring current American thought before a wider public.

L. Dudley Stamp

METALLURGY OF CHROMIUM

Chromium

By Dr. A. H. Sully. (Metallurgy of the Rarer Metals No. 1.) Pp. xii+272. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1954.) 35*s*. net.

THIS book is described as the first of a series on the metallurgy of "what are commonly referred to as 'rare metals' ". The book is well printed and attractively illustrated, and contains much information of value to both students and research workers. It is divided into seven parts which deal with: (1) history and occurrence of chromium; (2) production of chromium ferro-alloys and pure chromium; (3) physical properties of pure chromium; (4) melting and casting, powder metallurgy and workability of chromium; (5) electroplating and properties of electrodeposits; (6) chromizing; (7) constitution and properties of chromium alloys.

The author's style is rather diffuse, and many sentences could be shortened without loss of clarity or subject-matter. In general, however, the writing is clear and easily understood, although occasional unfortunate mistakes or ambiguous sentences are to be found. Thus the statement on p. 254 is an incorrect description of the work of Raynor and Pfeil, and suggests the formation of a phase Cr_2Al_9 which does not exist, while the first two sentences of the paragraph 4.4.6. are unfortunate. These are, however, minor faults in a book which will be read with much profit by all who are interested in chromium

or its alloys. It emphasizes the difficulties of preparing the metal in a state of high purity, and also the lack of knowledge about the really pure metal. It is well established that the temperature variations of some properties, such as the electrical resistance, undergo abnormal and quite unexplained changes about room temperature, while the apparently unrelated change from brittle to ductile fracture occurs between 50° and 100° C., and is of extreme interest. The physical properties of transition metals such as chromium and their alloys are, in fact, a direct challenge to both theoretical and experimental workers, and a reading of this book will suggest many subjects for research. W. HUME-ROTHERY

A THEORY OF SOCIAL CHANGE

Political Systems of Highland Burma

A Study of Kachin Social Structure. By E. R. Leach. Pp. xii+324. (London: The London School of Economics and Political Science (University of London), and G. Bell and Sons, Ltd., 1954.) 35*s*. net.

THIS book, an account of the social structure of the Kachin–Shan population of north-east Burma, has a value quite independent of its descriptive content. To-day a very powerful and extensive school of anthropologists adopts what is known as the 'functionalist' approach. Institutions are thought of as functioning within a social structure which, itself, consists of individuals who are so connected up by social relations as to form an integrated whole. The social system is a functional unity and vice versa—the functional unit is a social system. All institutions support one another, all mutually determine one another, and the result will be the picture of a society in stable equilibrium.

Dr. E. R. Leach attacks this theory root and branch. He is interested in cultural change, and he frankly confesses that he finds no place for a theory of internal change in the functionalist approach. Why, he argues, should we suppose that equilibrium is 'normal'? Why should we even suppose that the societies hitherto pictured by functionalists as being in stable equilibrium really are so? On the contrary, there is every reason to suppose that these societies do change, that they are at any given moment in a state of flux. In fact, Dr. Leach goes on, the functionalists do not and have not described the societies as they really are. What they have produced as a true picture of these societies is, in fact, nothing but a highly intellectualized conceptual model; and the reason for this, to his mind, is that they are attempting to impart a precision into the mutual relationships of individuals in such societies which in fact does not exist.

The anthropologist is using a set of scientific, highly precise and highly abstract categories, and into these he is trying to fit the data of native life; but in fact the native himself does not express his social relationships except in a symbolic and highly inconsistent form. He expresses it, that is to say, through ritual. He expresses it through myth. These specific and concrete activities are, moreover, interpretable in many ways, and individuals manipulate them to suit their own self-interest and in particular their interest in acquiring power and authority. In this way the system of myth and ritual is ambiguous enough to permit shifts of power-structure and to legitimize such shifts of power-structure once they have occurred. Thus Dr. Leach would (I think) hold that only unless an anthropologist is prepared to take as his assumption the vagueness and inconsistency of myth and ritual can he advance an explanation of indigenous political and social change. If myth and ritual were as tidy as the functionalists' assumptions tend to make them, then there is no room for shifts of power and status within the system described. It is only when myth and ritual are regarded as being a sort of arsenal from which legitimizing authority can be extracted that a theory of indigenous change becomes possible at all.

The major part of the book is devoted to an attempt to work out this theory in terms of the Kachin–Shan population. Here again Dr. Leach is an iconoclast: he admits blandly that his own interpretation of their cultures is at variance with practically everything that has hitherto been published.

His view can be briefly put in the following way: we have here three sub-types of social structure—there is the Shan type, which is feudal and hierarchical; the Kachin *gumlao* type, which is equalitarian; and in between them, the Kachin *gumsa* type, which he maintains is in unstable equilibrium. This is a sort of cross-roads. It represents societies which are moving either from the *gumlao* to the Shan type or from the Shan type to the *gumlao* type. The *gumsa* type may move in either direction; its relations are not fixed. "I assume," he says, "that within a somewhat arbitrarily defined area—namely, the Kachin Hills Area—a social system exists. The valleys between the hills are included in this area so that Shan and Kachin are, at this level, part of a single social system. Within this major social system there are, at any given time, a number of significantly different sub-systems which are interdependent. Three such sub-systems might be typed as Shan, Kachin *gumsa*, Kachin *gumlao*. Considered simply as patterns of organisation, these sub-systems may be thought of as variations on a theme. The Kachin *gumsa* organisation modified in one direction would be indistinguishable from the Shan; modified in another direction it would be indistinguishable from Kachin *gumlao*. Viewed historically such modifications actually occur and it is legitimate to speak of Kachins becoming Shans or of Shans becoming Kachins. When therefore I, as an anthropologist, examine a particular Kachin or Shan locality I need to recognise that any such equilibrium as may appear to exist may in fact be of a very transient and unstable kind."

This thesis Dr. Leach pursues through material of great intricacy. Yet is this single example, drawn as it is from one particular area, typical of all situations? *Prima facie*, one would not think so. It is perfectly possible, and indeed highly probable, that certain communities are in fact in the state of equilibrium. On the other hand, it must be conceded that it was high time that a field anthropologist put his finger on a crucial difficulty in functionalist theory—that is, the great problems it raises in constructing theories of indigenous change. The importance of this book therefore stands independently of the truth or falsity of Dr. Leach's proof. Its major importance is as a well-deserved challenge to a dominant anthropological theory. S. E. FINER

THE RADON CONTENT OF THE ATMOSPHERE

By W. ANDERSON, PROF. W. V. MAYNEORD and R. C. TURNER

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MEASUREMENTS of the radon content of the atmosphere were made so long ago as 1905 by Eve[1,2] in Montreal, in 1908 by Satterley[3] in Cambridge and Ashman[4] in Chicago. The values obtained by these workers ranged from $2{\cdot}0 \times 10^{-14}$ to $2{\cdot}0 \times 10^{-13}$ curie per litre, and the results as a whole seemed to support the original suggestion of Elster and Geitel[5] in 1903 that the radon in the atmosphere arises mainly from the soil. These workers noted that the highest level of active material in the atmosphere was found in fog conditions. It is interesting to note that these early workers sometimes discarded the values obtained from smoky atmospheres as appearing to be high or erratic. Since this early work, little seems to have been added to the subject except for isolated series of measurements[6]. The subject seemed of importance only in laboratories where bulk radium was being handled[7]. Even in the case of the Meuse Valley fog of 1930[8], no observations of radioactive content were reported, although investigations were carried out on a large number of chemical constituents of the fog. The purpose of this article is to present measurements relevant to this subject which have been made by us during the past two years.

Early in 1952, a series of measurements was made of the radon contents of various rooms and laboratories in the Physics Department of the Institute of Cancer Research, Royal Cancer Hospital, London, by drawing air samples of 10,000 litres through fine-grain Whatman filter papers by means of a vacuum cleaner fitted with an air-flow meter. The activity of the filter-paper samples, which was afterwards shown to have a half-life corresponding to radium A, B and C, was estimated in a lead castle arrangement of known geometry using a *GM*4 Geiger counter and scaling system. The values deduced, assuming equilibrium, for various rooms, ranged from 2×10^{-15} curie of radon per litre upwards, depending to some extent on the past history of the particular site. Air samples taken on the roof of the building on sunny, dry days showed values of only 2×10^{-15} curie per litre, that is, fifty times less than the 10^{-13} average value found by the authors above.

Uncertainty as to the fraction of the atmospheric radium A, B and C being collected by such filter papers led to a series of measurements being made during which filter samples and whole-air samples were taken simultaneously, the latter being collected in previously evacuated flasks of known volume. The filter-paper activities measured with the Geiger system showed values only 2–3 per cent of those measured at the National Physical Laboratory on the whole-air samples. The latter measurements were made by transferring the air to a previously calibrated ion chamber and observing the ionization current when the radon had reached equilibrium with its solid decay products.

The inference at this stage appeared to be that the filter-paper method had a low collection efficiency of only 2–3 per cent, and that this might be the reason for the low values obtained. The ion chamber method of measurement seemed altogether less equivocal, and the construction was undertaken of a suitable three-litre chamber used with a Townsend balanced Lindeman electrometer. Before this equipment became available, the London 'smog' of December 1952 occurred and only the filter-paper method could be used for measurement.

The highest activity found on the filter papers on the first day of the smog proved to be equivalent to 8×10^{-13} curie of radon per litre, that is, four hundred times the clear, sunny day value of 2×10^{-15} curie per litre. If this value of 8×10^{-13} curie per litre in fact represented only 2–3 per cent of the total activity present, then the maximum activity of the smog on the first day could have been 4×10^{-11} curie per litre; but it must be remembered that the fraction of the active deposit collected under smog conditions may be much larger than in a clear atmosphere.

Using a reflectometer (and calibrations supplied by the Fuel Research Board) the blackenings of a daily series of filter-paper samples were converted into approximate weights in milligrams per cubic metre of solid matter from the air and these weights plotted against the measured activities of the samples. The resultant graph (Fig. 1) shows increasing activities with increasing weight of solid matter collected by the filter, from the lowest observed values to the highest figure of 3·8 mgm. per cubic metre found on the first day of the smog. There seems little doubt that when the solid matter in suspension consists of particles or aggregates of particles large enough to be collected by such filter papers, then the activity of the filter sample is related to the weight of solid matter collected by it. On the other hand, when the suspended particles are so small that the collection efficiency is very low, such a method could give a

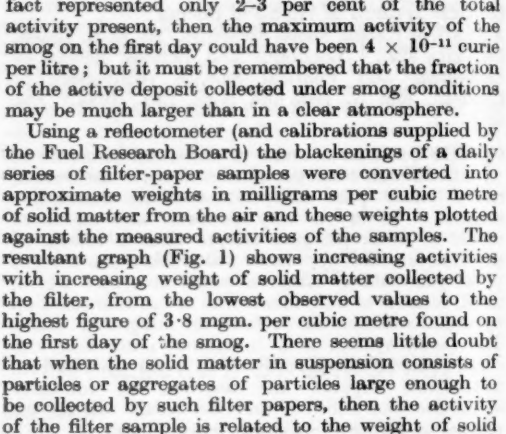

Fig. 1

low and completely misleading value for the atmospheric radon.

In May 1953, the ion-chamber apparatus became available and an extensive series of whole-air measurements was undertaken. The values obtained were greater by factors of 10–100 than those given by the filter-paper method, and the average roof value turned out to be $2–3 \times 10^{-12}$ curie per litre, which is some twenty times that obtained early in the century by the original workers. It was suggested that these higher figures might be specific to London, and in the absence of any further smog or even fog conditions attention was turned to the possible causes of this higher radon concentration. The explanation of the relatively high radon-levels observed during fog conditions may lie partially in the retention, by the fog blanket, of radon diffusing naturally from the soil and from city structures. These conditions could reduce the dilution normally arising from mixing with higher atmospheric layers. In seeking other relevant factors, we have been led to consider the possibility that a significant fraction of atmospheric radon is derived from the burning of coal.

A few studies[9–11] have been reported in the literature on the radium content of certain coals, and values found ranging from $0·05$ to $9·0 \times 10^{-12}$ gm. radium/gm. coal ash, or $0·001$ to $1·0 \times 10^{-12}$ gm. radium/gm. coal. We have carried out preliminary estimations on six samples of coal, as supplied for domestic use, and have found values ranging from 2 to 4×10^{-12} gm. radium/gm. ash, or $0·05$ to $0·3 \times 10^{-12}$ gm. radium/gm. coal. The measurements were made by estimating in the ion chamber the equilibrium radon released from samples of coal ash, using modifications of both classical methods, namely, boiling off from acid solutions, or fusion with alkali carbonates[12]. Some of the samples were taken from the combined ash obtained from the burning of several kilograms of domestic coal; later, more representative samples of known origin and rank were made available. The active material was characterized unequivocally by measuring its rate of decay and also the rate of decay of the 'active deposit' remaining in the ionization chamber after replacement of the gases with aged nitrogen. Good agreement was found between values obtained by the two methods. Careful control experiments conducted on the reagents used gave negative results.

Measurements have been carried out by the fusion method on the radon content of ash, derived from coal burned in a domestic grate, at various intervals after the burning process. The results indicate that 70–80 per cent of the equilibrium radon is liberated into the atmosphere during normal burning.

We have further demonstrated that the combustion of coal gas contributes to the atmospheric radon content. Preliminary measurements on coal gas, from the normal main, introduced directly into the ionization chamber, indicated the presence of radioactivity equivalent to about $0·5 \times 10^{-12}$ c. radon/lit. of gas. A simple method of concentrating the active material was devised in which the gas was burned with aged cylinder oxygen and the combustion gases led into the ionization chamber after removal of carbon dioxide and water vapour. In this way a five- to seven-fold concentration was achieved, and at the same time the gases were freed from undesirable tarry constituents. The activity was shown to be due to radon, using the same criteria described above. Values obtained in several tests over a few weeks ranged from $0·3$ to 1×10^{-12} c. radon/lit. coal gas. Careful control was again exercised on the reagents and equipment employed in this work. Successive positive results of the same order of activities obtained over several weeks using the same cylinder of oxygen removed the possibility of radon contamination from this source.

The need for great care in these experiments was emphasized in earlier tests which we had conducted and in which rather higher radon values than quoted above had been found from coal gas combustion. In a control run designed to parallel the combustion experiment, carbon dioxide and nitrogen from cylinders were passed through the combustion assembly; approximately half the amount of radon found in the test run was measured in this control. It was discovered that the radon appearing in the control had been liberated from the soda-lime used for the absorption of carbon dioxide. An independent estimation placed the radium level in the soda-lime at $0·25 \times 10^{-12}$ c./gm. Under the experimental conditions during combustion, approximately 100 gm. soda-lime were used, and were found to yield 9×10^{-12} c. radon (= 36 per cent total radon available). This phenomenon, unusual in that the radon is liberated under comparatively mild temperature conditions (the soda-lime is warmed to 60–80° C. by the heat of reaction), might be understood in terms of the rupture of the occluding structures caused by the chemical changes accompanying absorption of carbon dioxide. In subsequent work the soda-lime was replaced by solutions of potassium hydroxide; the control runs were then found to give negative results. It is interesting to note that the classical fusion method of radon estimation[12], which gave values generally double those obtained from the corresponding solution method, employed soda-lime tubes for removal of the carbon dioxide evolved.

It is not possible at present to assess with any accuracy what fraction of atmospheric radon may be attributed to the burning of coal and coal gas. There are wide variations with respect to time and location of the contributions from such processes, and furthermore, comparatively few figures are available on atmospheric radon-levels. The radium content of coal, and the radon content of coal gas, appear very small when considered per gram of coal or per litre of coal gas; but, on the other hand, these materials are consumed in very large quantities daily. For example, in the Greater London Area during 1953, the daily consumptions were: coal, 55,000 tons, and coal gas, 10^{10} litres. It would therefore seem desirable that further information be obtained on the significance of such contributions to total radon concentration in the atmosphere. The increased levels measured during fog conditions would find at least partial explanation if these processes are significant.

We are at present extending the scope of our measurements of the radium content of British coals and of atmospheric radioactivity at a variety of locations. The work forms part of a wider research into possible health hazards associated with prolonged exposure to small amounts of radioactive materials.

We gratefully acknowledge the help of Mr. W. J. Callow, of the National Physical Laboratory, and Dr. E. T. Wilkins, of the Fuel Research Board. We are also indebted to Sir Charles Ellis and Mr. A. M. Wandless (National Coal Board) for providing coal samples. Acknowledgments are also due to the Governors of the Royal Cancer Hospital, who sup-

ported the work by a fellowship to one of us (W. A.). Valuable technical assistance in the experimental work was given by Mr. J. O. Crookall.

[1] Eve, A. S., *Phil. Mag.*, **10**, 98 (1905).
[2] Eve, A. S., *Phil. Mag.*, **14**, 724 (1907); **16**, 622 (1908).
[3] Satterley, J., *Phil. Mag.*, **16**, 584 (1908).
[4] Ashman, G. C., *Amer. J. Sci.*, **26**, 119 (1908).
[5] Elster, J., and Geitel, H., *Phys. Z.*, **4**, 138, 522 (1903).
[6] Dawson, K. B. *Brit. J. Cancer*, **6**, 22 (1952).
[7] Read, J., and Mottram, J. C., *Brit. J. Radiol.*, **12**, 54 (1939).
[8] Firket, J., *Trans. Farad. Soc.*, 64th Discussion. Disperse Systems in Gases, p. 1192 (April 1936).
[9] Lloyd, S. J., and Cunningham, J., *Amer. Chem. J.*, **50**, 47 (1913).
[10] Moureu, C., and Lepape, A., *C.R. Acad. Sci.*, **158**, 598 (1914).
[11] Drakeley, T. J., and Smith, F. W., *J. Chem. Soc.*, **121**, 221 (1922).
[12] Rutherford, E., "Radioactive Substances and their Radiations" (Camb. Univ. Press, 1913).
[13] Joly, J., *Phil. Mag.*, **22**, 134 (1911).

NEW FACTS ABOUT COELACANTHS

By Prof. J. MILLOT
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THE researches upon the Coelacanths which my co-workers and I are actively pursuing, not only in the Muséum National d'Histoire naturelle at Paris and the Institut de Recherche Scientifique de Madagascar but also in the field round about the Comoro Islands, are gradually bringing into sharper focus our picture of these remarkable fishes. I have already published various papers and observations concerning them in *La Revue de Madagascar* (December 1953), in the Paris *La Nature* (April 1954), in *The Times* (June 3, 1954) and in a bulky supplement to *Le Naturaliste Malgache* (June 1954). In the present article I am able to present further new information.

From the point of view of anatomy, we are still in the initial period of descriptive studies: comparisons and interpretations, though so very tempting, would still be premature. In my article in *The Times* I have given the first indications of the arrangement of the heart and of the persistence of a vestige of a pulmonary organ. To these I am now able to add observations relating to the digestive system and kidney.

The œsophagus, remarkably wide, strongly fluted along its length and very muscular, allows the animal quite easily to swallow entire living fishes of fifteen centimetres or more, for such have been recovered intact. It is continuous with the stomach, without any anatomical differentiation: the transition from one organ to the other cannot be distinguished save under the microscope, following the transformation of the mucosa and the appearance of the characteristic long, tubular glands of the fundus present throughout the vertebrate series and already perfectly differentiated in the Coelacanths. The stomach is, like the œsophagus, very capacious, longitudinally furrowed and yellowish in colour. Its thick musculosa is exceptionally dense. Its shape is that of a V opening anteriorly and having two wide limbs of unequal length: the dorsal one, following directly upon the œsophagus, is relatively short (twenty centimetres or so) although the blunt point of the V is situated beyond the opening of the cloaca; the other limb, ventral and of more than double the length, gradually narrows and ends by a tubular pyloric portion curved into a knee-bend in the anterior part of the abdominal cavity. It opens through an annular sphincter (the pronounced differentiation of which contrasts with the total absence of a cardia) into a very short chamber, an adumbration probably of the bursa entiana or *zwischen darm* which is found more or less developed in many fishes. This, devoid of any appendage or cæcum, is in the Coelacanths no more than the antechamber to a sub-fusiform spiral intestine *en rouleau* showing nearly a score of concentric turns.

This spiral intestine, in one form or another characteristic of primitive fishes, is directly followed by the hind-gut (coprodæum), in which may be distinguished (*a*) a sub-horizontal rectum which rises in its terminal portion at the level of the vent to bend at a right-angle towards this, and (*b*) a cloacal pouch directed almost vertically downwards and the inner posterior wall of which bears a urino-genital papilla and receives besides the secretion of a median and unpaired nodular gland which is bound to it. The latter, of serous type, surrounded by a tough capsule and the size of a large hazel-nut, is of very dense texture and exceptionally firm consistency; it is probably homologous with the digitiform gland of Selachians, although of very different structure. The inner walls of the rectum and cloaca are thin and distensible, but reinforced by longitudinal muscle bands.

The liver, the pale slate colour of which varies appreciably from one specimen to another, comprises two lobes: the right occupies two-thirds of the length of the visceral mass; the left is a little broader but only about half as long. The hepatic cells are rich in fatty inclusions, but not specialized more or less exclusively for the storage of fat reserves as is the case with many sharks. The gall-bladder, partially buried in the bridge of connecting tissue which unites the anterior ends of the lobes of the liver, is relatively voluminous; by tapping that of specimen C^2 I was able to extract 50 c.c. of bile.

The pancreas, also well developed, forms a long yellow band, in section triangular, in structure partly fatty, occupying on the right side of the visceral mass all the depression situated between the ventral branch of the gastric V, the spiral intestine and the rectum.

The kidneys are fused together into a single median organ the position of which is unusual: it is in fact applied to the ventral wall of the abdominal cavity, behind the cloacal opening, although the testes are situated in the middle of the dorsal part of the visceral mass and therefore entirely pre-cloacal. There are two symmetrical ureters the free portions of which are quite short and expand dorsally each into a voluminous ear-shaped bladder. The bladder is thus in Coelacanths a paired formation, though the kidney is unpaired—an uncommon arrangement. The urethras approach symmetrically toward the sides of the urino-genital papilla before opening into it.

The kidney is provided with large pine-cone-shaped glomeruli and with well-developed Malpighian tubules. Its structure, markedly different from that of other fish kidneys which I have had occasion to examine, is of the highest interest; but it is complicated and requires prolonged and intricate study. Eosinophile secretions have been observed in certain tubules, as well as cavities lined with ciliated epithelium, which are probably nephridial but the disposition of which I have not yet been able to work out. Unlike that of many Teleosteans, the kidney does not contain any lymphoidal tissue, but shows considerable infiltrations of pseudo-eosinophile leucocytes. The extreme abundance of these leucocytes, their intense and diffuse hæmapoiesis, the more or less penetrating

sheaths which they form around the greater part of the abdominal organs, seem likewise to be one of the histological peculiarities of the Coelacanths.

From the point of view of biology, some quite recent complementary investigations which I have just carried out with Commander Cousteau and his team from the *Calypso* confirm that the modern Coelacanths inhabit, around the Comoro Islands, basalt rocky bottoms which slope very steeply (25°–45°). They seem to live normally on the actual bottom or quite close to it, between 200 and 400 metres depth at least; specimen C^4, for example, was taken fifty centimetres from the bottom in a depth of 370 metres and over a slope of 45°. But there is every possibility that their habitat may extend very much deeper still. It would be as well, in fact, to emphasize that fishing off the Comoro coasts has never yet been carried out beyond 370–380 metres depth, and that two of these fishes have been taken at that extreme limit. The fact, moreover, that among the five specimens captured there is no adult female leads us to believe that these may be out of reach because they live at a depth of more than 400 metres.

An attractive theory has been formulated in Grand Comoro, where the last three specimens were taken: namely, that the Coelacanths live in the upwellings of fresh water off that island, the hydrographic conditions of which are very peculiar. There is a great deal of rain—more than 5 metres rainfall per annum in certain places—but nevertheless the island suffers from a serious and permanent shortage of water. There is not a single river, and even after the heaviest downpours there is an almost complete absence of surface water; this is because the soil is formed of very permeable volcanic scoria into which practically the entire rainfall is absorbed. This then flows away into the sea by a multitude of coastal springs and important submarine upwellings, in such a way that during a spell of drought, when the level of the reservoirs falls in the most alarming manner, the people often come at low tide to draw water from these littoral springs. Now Coelacanths, as we know, have during long periods in the past lived in brackish or nearly fresh waters—from which comes the very interesting notion that they may have been able to survive among the Comoros, and among the Comoros only, because the submarine upwellings of fresh water would have assured them the maintenance of their ancestral environment at depths where reduced competition allowed them a better chance of existence.

Complete transverse section through the anterior quarter of the abdominal viscera of Coelacanth C^4.

Note, in the centre of the upper portion, the œsophagus (wrinkled opening) and, closely applied to its ventral surface, the vestige of the pulmonary organ, represented by a fatty crescent-shaped mass centring around a very short tubular diverticulum. The centre of the photograph is occupied by the two large hepatic lobes, here very dark. Below these lies the spiral intestine. At the very bottom of the illustration is the narrow pyloric region of the stomach with, to its left, the pancreas, which is triangular in section.

Preparation made with the collaboration of Dr. Decérisy. Photo: J. M. Bauflé

Unfortunately, the most ingenious explanations are not always the true ones. This one does not seem to be tenable because, for one thing, the upwellings in question do not seem to occur except in the intertidal zone; and again, because also the seawater samples taken by my collaborator Menaché in the places where the Coelacanths of Anjouan were captured have revealed quite normal marine salinities. Further, there is every likelihood that the samples of water which have just been obtained by the *Calypso* at the location and depth at which the first Coelacanth of Grand Comoro was taken will produce similar results.

[Translation by Denys W. Tucker, British Museum (Natural History).]

NEWS and VIEWS

James Cook Medal of the Royal Society of New South Wales : Sir David Rivett, K.C.M.G., F.R.S.

The Royal Society of New South Wales has awarded the James Cook Medal for 1953 to Sir David Rivett. The presentation was made by the president of the Society, Prof. R. S. Nyholm, of the N.S.W. University of Technology and professor-elect of chemistry in University College, London. Prof. Nyholm remarked that Sir David Rivett, after graduating at the University of Melbourne, proceeded in 1907 as a Rhodes Scholar to Oxford. At Oxford, and later at the Nobel Institute, Stockholm, he carried out research in physical chemistry. He returned to Australia as lecturer in chemistry at the University of Melbourne in 1911, where he succeeded Sir David Orme Masson in the chair of chemistry in 1924. His main research interests were in the field of heterogeneous equilibria, to which he made many major contributions. Rivett had frequently stressed the importance of scientific research in the development of Australian primary and secondary industries. It was not surprising, therefore, that when the Institute of Science and Industry was reconstituted in 1926 as the Council for Scientific and Industrial Research, the Commonwealth Government appointed him as the chief executive officer and deputy-chairman. The success of the Council (now the Commonwealth Scientific and Industrial Research Organization) has been due, in a large measure, to Rivett's vision and leadership. Many difficulties were encountered in the formative years through Federal and State jealousies, impatience of politicians expecting quick results, and the often niggardly provision of money by Governments. Rivett overcame these difficulties by his persuasiveness in negotiation, courageous public utterances and his high personal and scientific integrity. The growth of fundamental research work in the Council was constantly encouraged by Rivett and, by the time he retired from direct work with the Council in 1949, fundamental studies occupied a major part of its activities. Rivett's leadership in science has been recognized by the conferring of a knighthood in 1936 and election to fellowship of the Royal Society in 1941. He was president of the Australian and New Zealand Association for the Advancement of Science during 1936–39 and president of the Society of Chemical Industry of Great Britain in 1950. The James Cook Medal is awarded annually "for outstanding contributions to Science and Human Welfare in and for the Southern Hemisphere".

Indian Independence Day Decorations

Among decorations awarded by the President of India on Independence Day were the following :

The Bharat Ratna to Sir C. V. Raman, F.R.S., director of the Raman Research Institute, Bangalore.

The Padma Vibhushnan Pahela Varg (first class) to Dr. S. Bose (physicist) and Dr. Z. Hussain (educationist).

The Padma Vibhushnan Dusra Varg (second class) to Dr. H. J. Bhabha, F.R.S., director of the Tata Institute of Fundamental Research, Bombay ; Sir Shanti S. Bhatnagar, F.R.S., secretary to the Ministry of Natural Resources and Scientific Research and director of Scientific and Industrial Research, Government of India ; and Sir K. S. Krishnan, F.R.S., director of the National Physical Laboratory of India, New Delhi.

Agriculture at Reading : Mr. A. N. Duckham, C.B.E.

The appointment of Mr. A. N. Duckham to the chair of agriculture at Reading in succession to Prof. H. G. Sanders (see *Nature*, April 10, p. 662) will be warmly welcomed. From the Agricultural VI at Oundle he went in 1922 to Cambridge, where he took the Natural Science Tripos and the diploma in agriculture. In the latter he obtained the very rare 'distinction', and an essay based on his thesis work on baby beef was awarded the silver medal for research by the Royal Agricultural Society of England. From 1927 onwards he was concerned mostly with pigs at Cambridge (where with Mr. H. R. Davidson he started and ran the East Anglian pig recording scheme), Belfast and Aberdeen, and in 1935 he became the research officer of the Bacon Development Board. In addition, he carried through two special assignments with conspicuous success : a survey of the economics of grass drying for the Empire Marketing Board, and the preparation of an account of animal industry in the British Empire which involved much travel. War brought service with the Ministry of Food as chairman of that Ministry's agricultural committees and collaboration with Sir Jack Drummond on dietary problems in Great Britain and other countries. He attended the Hot Springs Conference in 1942 and has continued as agricultural adviser to the United Kingdom delegation to the U.N. Food and Agriculture Organization. In 1945 he was appointed agricultural attaché at Washington, where he was extremely successful. After his return to become head of the General Division of the Ministry of Agriculture, he produced a monograph on American agriculture which is held in very high esteem. The University of Reading will gain one whose knowledge of agriculture is almost world wide, and whose interests also include painting and music.

Bernard Price Institute of Geophysical Research, Johannesburg : Prof. A. L. Hales

The University of the Witwatersrand has appointed Prof. A. L. Hales to succeed Dr. B. F. J. Schonland as director of the Bernard Price Institute of Geophysical Research, Johannesburg, when the latter leaves on October 1 of this year to take up his new position in Britain as assistant director of the Atomic Energy Research Establishment, Harwell. Prof. Hales, who at present occupies the chair of applied mathematics in the University of Cape Town, took his M.Sc. degree at the University and then proceeded to Cambridge, where he studied under Sir Harold Jeffreys. His first university appointments were in the Departments of Mathematics and of Applied Mathematics at the University of the Witwatersrand. After war service, including geophysical work in the Middle East theatre, he served on the staff of the Bernard Price Institute during 1945–49 before proceeding to Cape Town. Prof. Hales has made a number of important contributions to geophysical subjects connected with the crustal structure of the earth and the theory of mountain building. Some years ago he carried out a gravity survey of southern Africa in association with Dr. D. I. Gough.

National Institute of Agricultural Botany, Cambridge: Report for 1953

At the annual general meeting of the Fellows of the National Institute of Agricultural Botany, Cambridge, on July 16, the chairman, Prof. T. J. Jenkin, presented the annual report of the Council for the year ending December 31, 1953 (pp. 48. From the Institute), and referred to some new developments in the work of the Institute proposed for the future. From the report, it is evident that the year under review was one of both progress and consolidation, and the improved staffing, authorized by the Ministry of Agriculture in 1952, has been fully implemented. Since publication of the results of field trials is one of the Institute's chief concerns, it is satisfactory that two issues of its *Journal* appeared during the year, together with new or revised editions of seven "Farmer's Leaflets", while interim comments on the performance of some seventy different varieties of cereals, varieties or strains of root and fodder crops, beans, peas, vegetables and potatoes were available in the report itself. Development of the Field Inspection and Certification schemes co-ordinated by the Seed Production Committee of the Institute continued, and the acreage of cereal seed crops inspected under the Field Approval Scheme reached a total of 66,000 in 1953, compared with 26,800 in 1947.

As regards the future, Prof. Jenkin announced that the Ministry of Agriculture has agreed to the request of the Welsh Plant Breeding Station that the Institute should accept responsibility for the production of stock seed and for the certification of the Aberystwyth strains of grasses and clovers. It is recognized, however, that two or three years must elapse before the necessary equipment and facilities can be provided to enable the Institute to undertake full responsibility in this matter. Developments in the international field are also contemplated, for help of the Institute has been sought by the Organization for European Economic Co-operation to co-ordinate two new projects. The first of these is a scheme for international grass strain trials designed to test the value of strains. This will involve three stages—namely, identification and classification, preliminary assessment and agronomic trials—and will be undertaken in close co-operation with the Grassland Research Station at Hurley. The second is an attempt to obtain greater uniformity in the terminology used to designate the different stages of herbage seed production, for at present each country has its own system, and confusion is liable to occur with regard to certification schemes. The meeting concluded with an address by Sir John Russell (see p. 446 of this issue).

The Royal Botanic Gardens, Kew

With the publication of the first number of the *Kew Bulletin* for 1954, the work of the Royal Botanic Gardens, Kew, during 1953 is reviewed in some detail. This is a matter of general interest, to the public and to professional botanists alike. During the year the centenary of the Herbarium and Library was celebrated by an exhibition illustrating the work of these Departments during the past hundred years (see *Nature*, 171, 1086; 1953). The continuing activity of the herbarium is well illustrated by the following statistics: specimens received from outside sources, 60,496; sheets received on loan, 4,558; sheets sent on loan, 4,446; sheets distributed as duplicates, 12,268; sheets mounted (with certain exclusions), 46,465; and so on. Visits by botanists numbered 3,964. Inquiries and plant consignments dealt with numbered 2,667. In the midst of the routine tasks, of which there are many, the long-term projects have been pursued, for example, the preparation of the "Flora of Tropical East Africa", and other floras, and members of the staff have taken an active part in contemporary botanical and other activities. Special work on particular systematic groups has also been undertaken, for example, Bignoniaceae, Orchidaceae, vascular cryptogams, etc. An outstanding event of the year was the publication of Supplement XI (1941–50) of the *Index Kewensis*, and progress has been made with the succeeding volume. The work of the Library, the Museum and of the Jodrell Laboratory, where work on the systematic anatomy of the monocotyledons is being steadily pursued, as well as routine inquiries, some of a curious character, is also reviewed. In the Gardens, the work in the arboretum, the alpine and herbaceous sections, and the temperate, decorative, tropical and other departments is recorded and discussed. The *Bulletin* concludes with a list of publications and the roll of scientific and administrative staff.

Science in China To-day

An interesting but pessimistic appreciation of the position of scientists in Communist China is contributed to *Science* (119, 785; 1954) by A. Z. Chang, now working at the Centre for International Studies, Massachusetts Institute of Technology. Reviewing the education and activities of those of the fifty scientific workers constituting the national committee of the 'Ko-lien' (All-China Association for Natural Sciences) for whom information is available, Dr. Chang points out that their average age so far as is known is more than fifty-five years, and none is a product of post-war education. Of the eleven institutes within the Academia Sinica, six are directed by leading scientists who are members of the 'Ko-lien' National Committee and three others by scientists who are not members of that Committee. Most of these leading scientists retain their teaching positions while serving in government positions; of the fifty members of the 'Ko-Lien' National Committee, fifteen retain full-time professorships and five serve on committees. A few hold key positions in functional departments. Throughout the Second World War there was no evidence that the Communists made any progress in training or absorbing scientific personnel, while the leading scientific workers of the older generation are being subjected gradually to as great pressure as any other intellectual group. Dr. Chang considers that the most serious challenge is the particular Communist concept of science in general and the Communist inherent antagonism against 'bourgeois science' in general; in main construction projects the Communists rely more on their ability and ruthlessness in organizing masses than on technical knowledge. Indigenous technology and the scientific approach on the China mainland are in a highly State-controlled condition to-day, and the future of science in this area is likely to conform to that within the general Soviet pattern.

Scientific Research in South African Universities

The Library and Information Division of the Council for Scientific and Industrial Research, Pretoria, has published a "Register of Current

Scientific Research at South African Universities" (pp. 212; 1953), this being the second volume, the first volume, covering research in progress during 1951, having been issued in 1952, and it is hoped to issue the register annually in future. It is a companion to the "Register of Current Research in the Humanities", issued annually since 1946 by the Council. Investigations are arranged by subjects according to the university department, with occasional cross-references, and the departments are listed alphabetically under their English names. Details of the scope of the investigations are given in the language in which it was received from the university department, but the omission to translate subjects or titles consistently into English somewhat militates against the usefulness of the register. Particulars of the qualifications and status of the investigator and of the director of the investigation are included.

East African Research Board: Report for 1953

The eleventh annual report of the East African Industrial Research Board of the East African High Commission (pp. 11. Nairobi: Government Printer, 1954) covers the year ended December 31, 1953, and records good progress in the project to extract hecogenin from sisal waste on a pilot scale. Pure hecogenin acetate is now becoming available in the United Kingdom in research quantities for the synthesis of cortisone and related compounds, and a hydraulic press and extrusion cylinder has been designed for the expression of juice from sisal waste which should prove more efficient than the squeezing rolls hitherto used. Work on the refining of sisal wax indicates that fractional extraction with alcohols will yield more highly coloured fractions first, which might be used where colour is unimportant, and that later fractions might be used to obtain a paler product. The method of pelletizing fine kainite for heating in a rotary kiln has been worked out on a commercial scale, and the addition of alumina as bauxite has proved to be the most reactive for converting the silica, released from the kyanite molecule on calcining, to mullite. Detailed performance tests have been made on the use of wood producer gas in dual-fuel diesel engines, but experiments on the fermentation of sisal waste and papyrus roots and stalks to give combustible gases had to be suspended, although yields of 400–500 c.c. gas containing about 60 per cent of methane and 40 per cent carbon dioxide can be expected per gram of dry sisal waste with an output 0·9–1·5 times the volume of the digesting mass per day. Preliminary experiments indicate the possibility of producing pepsin of more consistent quality by processing the latex obtained from the juice of the pawpaw fruit. Trials with a Swiss mechanical briquetting machine indicated that the machine was unsuitable for handling coffee parchment, cotton seed husk and brine coffee husk without further treatment, but excellent briquettes were obtained from sawdust and satisfactory briquettes from brine coffee husk which had been passed through a disintegrator. An investigation into the whole process of coffee curing was commenced.

National Foundation for Scientific Research, Brussels: Report for 1952–53

The twenty-sixth annual report of the National Foundation for Scientific Research, Brussels, covering the year 1952–53 (pp. 231; 1954), records the completion under the Inter-university Microfilm Commission, created in October 1949, of an inventory of microfilms in the archives of the French Departments of Lille and Dijon, copies of which are deposited in each of the Belgian universities. The Council made a third grant of 1,485,000 francs to the Special Commission for Clinical Research, which has been distributed by the Commission among the four university centres engaged in work on cortisone and adrenocorticotropic hormone, and brief reports from each centre on this work, with a list of publications, are included. A sum of two million francs was put at the disposal of the Royal Observatory of Belgium for the establishment of a radioastronomy laboratory. Brief accounts are included of the work on calculating machines at the Universities of Brussels, Ghent, Liège and Louvain, for which a further credit of 50,000 francs has been voted, while 200,000 francs were voted for the reconstruction of the Marine Biology Station at Wimereux, destroyed during the War. Ninety-three grants, totalling 247,289 francs, were made to assist Belgian scientists and research workers to attend overseas conferences and meetings. Extraordinary credits granted during the year, totalling 6,110,000 francs, included two million francs to the Inter-university Microfilm Commission, 25,000 francs to the International Institute of Meteorology, Stockholm, 50,000 francs to the Zoological Station, Naples, and 250,000 to Prof. R. de Langhe for his archæological expedition to explore systematically the grottoes of the borders of the Dead Sea and the desert of Judea in Palestine. Lists of recipients of research grants for 1953–54 and of publications during 1952–53 by recipients of grants are included. The report includes an account of the distribution of radioisotopes in Belgium and the researches carried on by this means in the university laboratories and at the Institute of Cancer, as well as in the Polytechnic Faculty of Mons, the State Agronomie Institute at Gerbloux and in industry and horticulture.

Central American Scientific Institutions and Scientists

A first list for Central America in the series "Scientific Institutions and Scientists in Latin America", covering Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama (pp. 202; 1954), has been issued by the United Nations Educational, Scientific and Cultural Organization, at Montevideo. The list was prepared by the Organization's Field Science Co-operation Office for Latin America, with the collaboration of Ibero-American organizations, and is expected to be completed in several volumes during the next few months. Under each country are given lists, in Spanish, first of institutions and second of scientific workers; these include the address of the institution and some details of its functions, interests and officials, and, for the scientists, of their special interests, career and publications.

The Scientist: A New Pakistani Journal

In Nos. 2 and 3 of the first volume of a new journal, *The Scientist*, which has recently been started in Pakistan, there are articles upon the following topics: the agricultural industries of Pakistan; the problem of Pakistan railways; symmetrical incomplete block designs; a field key to the identification of fishes; the biology of a mango defoliator; and the theory of liquids. *The Scientist*

is published by the Department of Zoology, University of Karachi, the chief editor being Dr. M. A. H. Qadri.

Scientific Literature in New Delhi

THE "Insdoc List of Current Scientific Literature", the first issue of which is dated June 1, 1954 (pp. 16. New Delhi: National Scientific Documentation Centre; Rs. 10 a year), is being published semi-monthly to inform scientific workers in India and neighbouring countries of the latest papers published in some two hundred and fifty leading scientific and technical periodicals of the world. It also includes information on scientific reports received at the National Physical Laboratory—Insdoc Library, New Delhi, as well as the titles of translations available or on which information has been received. Titles of papers in languages other than English are given in English translation. The entries are arranged in broad subject groups according to the Colon Classification, but Universal Decimal Classification numbers are also given.

Bibliography of French Biological Books

THE first issue (No. 9, December 1953) of the second series of the "French Bibliographical Digest", which is planned to give a selected bibliography of significant scientific and technical books, of at least university level, published in France since 1949, includes an article by Prof. L. Plantefol on botany in France to-day and a list of French scientific and technical periodicals. Under each subject the abstracts or reviews of each book are given alphabetically by authors, and there is also an index of authors. The entries in this issue are limited to biology, botany and zoology, and the Digest is intended primarily to introduce French books to the United States. It will be supplied free, upon request, to libraries, university departments and scientific workers who indicate the subjects in which they are interested. It is edited and published by the Cultural Division of the French Embassy, 972 Fifth Avenue, New York City, 21.

Yale Medical Library and Historical Library: Report for 1952–53

THE annual report of the Yale Medical Library, which includes the report of the Historical Library, for the year ended June 30, 1953 (pp. 47. New Haven, Conn.: Yale Medical Library, 1953), stresses changes made to increase the availability of periodicals. The 'current use' of a periodical appears to continue for about five years, the second year after publication being the time of heaviest use and also the time when the periodical is at the binders. Two periodicals were used as much as 158 of the least popular on the list combined, and with thirty-eight others these two periodicals accounted for nearly 50 per cent of the use made of periodicals. By duplicating subscriptions to the more heavily used periodicals, discontinuing the binding of four hundred little-used periodicals, restricting the more complete set to use within the Library, and certain other changes, it is hoped to check the sharp decline in the recorded use of the Library. A list of periodicals available in the reading room is appended, and the report of the Historical Library gives details of important accessions during the year.

The Early Developments in Atomic Energy

AT the meeting of the Education Group of the Institute of Physics on October 20, 1953, Prof. O. R. Frisch, of the University of Cambridge, who was one of the pioneer workers in the atomic energy project during the Second World War, delivered an interesting talk on "Atomic Energy—how it all Began". The text is reprinted as a special article in the March number of the *British Journal of Applied Physics* (5, 81; 1954). Prof. Frisch gives a brief review of important developments following the first direct manifestation of atomic energy by Becquerel in 1896, in particular of Rutherford's 1912 picture of the atomic nucleus and of Chadwick's discovery of the neutron in 1932. He then discusses why physicists with all the data available in 1935 did not discover fission at that time. Next, the exciting events which followed Hahn and Strassmann's publication in 1939 are most vividly told, and Prof. Frisch includes some personal reminiscences of details of his conversations and discussions with Prof. Lise Meitner. Finally, the feasibility of controlled and explosive controlled reactions and the development of controlled nuclear reactors are discussed. Prof. Frisch concludes by remarking that he likes to remember the days when chain reactors were a new toy for physicists to play with and recalls how for a few exciting weeks in Los Alamos he and others were allowed to study the growing amounts of uranium-235 which were then being prepared for the first atomic bomb.

Diamond Tool Industry during 1953

AN eight-page brochure, entitled "The Diamond Tool Industry in 1953", issued free of charge by the Industrial Diamond Information Bureau, 32–34 Holborn Viaduct, London, E.C.1, is the ninth in the series of reports on the diamond tool industry and summarizes the main developments during 1953 under the following headings: physical properties; hardness; surface finish; fine boring and turning; trueing of grinding wheels; diamond powders; impregnated diamond tools; sintered carbide grinding; glass grinding and stone working; rock drilling; wire drawing; diamond use and salvage; new machining methods; and jewel bearing production. Reference is made to 155 articles, and a detailed bibliography is appended. The report, which will be of interest to all those engaged in the use and production of diamond tools, has been compiled from the monthly "Bibliography of Industrial Diamond Applications", also published by the Industrial Diamond Information Bureau.

Protecting Cleaned Iron Objects

IN the *Museums Journal* of May 1954, L. Biek, E. S. Cripps and D. M. D. Thacker, of the Ancient Monuments Branch, Ministry of Works, describe a series of experiments undertaken to protect iron objects that have been cleaned. Some keys, of the eighteenth to early nineteenth centuries, were used. All were heavily rusted, with some deep pockets of hard oxide. The keys were cleaned in an inhibited phosphoric acid formulation ('Deoxidine No. 125', I.C.I.) and scrubbed with steel wire brushes to remove the rust. They were then soaked in acetone to prevent the formation of the rust-coloured film which appears when wet ironwork dries in air. Various protective coverings were then applied, including bleached beeswax, chlorinated rubber solution, celluloid solution, polyvinyl acetate solution in toluene, polymethacrylic ester solution ('Bedacryl' 144 TL., I.C.I.) and graphite powder rubbed into the surface. The amount of rusting was assessed

and other factors, such as convenience, cost, time and appearance, were taken into account. By and large, waxing seems to have a slight advantage over steel wire brushing followed by 'Bedacryl'; coating with polyvinyl acetate and the graphite/'Bedacryl' treatment are also satisfactory.

Education for Management

The British Institute of Management has now published the second of the booklets dealing with education and training in the field of management. The first was concerned with the facilities available in technical colleges and other educational institutions, while the second describes short courses held at residential establishments and by professional and other bodies. These include courses for senior management organized at the Administrative Staff College and by the National Council of Y.M.C.A.'s; courses for middle management and other supervisors arranged by certain professional and voluntary organizations, adult education colleges, university departments and such bodies as the Hull Junior Chamber of Commerce; courses for young workers, apprentices and other entrants to industry, organized mainly at residential educational colleges; courses for trade unionists organized mainly by the National Council of Labour Colleges; as well as courses in such topics as joint consultation, communications, work study and method engineering held at a variety of centres. The booklet also contains details of special courses arranged for education, training and personnel officers. The sponsors of the booklet are to be commended both for undertaking such an important work and for the succinctness and accuracy of their presentation.

The Fourth Douglas Lea Memorial Lecture

The fourth Douglas Lea Memorial Lecture, entitled "Douglas Lea: Physicist into Biologist", will be delivered by Prof. C. A. Coulson, Rouse Ball professor of applied mathematics in the University of Oxford, at a meeting of the Hospital Physicists' Association on October 1 in the Reid-Knox Hall of the British Institute of Radiology, 32 Welbeck Street, London, W.1, at 8 p.m. The meeting is open to the public.

Announcements

The eighth annual congress and festival of scientific films of the International Scientific Film Association will be held in Rome during November 6–12 at the University City and also at the National Research Council. Public performances of outstanding films of general appeal will be given, and specialized films will be shown and papers read at the meetings of the sections concerned with the film in medicine and veterinary science, in industry and technology, in scientific research, and in other subjects. Inquiries in Britain concerning the congress should be sent to the Scientific Film Association, 164 Shaftesbury Avenue, London, W.C.2. All other inquiries should be sent to the Segreteria VIII Congresso Internazionale della Cinematografia Scientifica, Commissione per la Cinematografia Scientifica del Consiglio Nazionale delle Ricerche, Piazzale delle Scienze 7, Roma.

The fourth annual Eastern Joint Computer Conference and Exhibition, which is jointly sponsored by the American Institute of Electrical Engineers, the Institute of Radio Engineers and the Association for Computing Machinery, will be held in the Bellevue–Stratford Hotel, Philadelphia, Pa., during December 8–10, the theme this year being the "Design and Application of Small Digital Computers". Proceedings of the Conference will be published by the sponsoring societies and may be ordered from any one of them. The meeting will be open to all. Applications for registration should be sent to the Eastern Joint Computer Conference, P.O. Box 7825, Philadelphia 1, Pa.

The Iron and Steel Institute, in association with the Institute of Metals, is organizing a symposium on powder metallurgy, to be held in Church House, Westminster, London, S.W.1, during December 1–2. Both ferrous and non-ferrous aspects of powder metallurgy will be considered, and there will be a small exhibition of components used in the various processes. The papers will be divided into three groups: metal powders and their assessment; research and production practice; and production and properties of engineering materials. The symposium will be open to all, whether or not they are members of either Institute, on application to the Secretary of the Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W.1, from whom further information can be obtained.

The autumn conference of the Scientific and Technical Group of the Royal Photographic Society will be held this year on October 2 in the Lecture Theatre of the Stephenson Building, King's College, Newcastle upon Tyne, in conjunction with the University of Durham. The theme will be "The Scientific and Technical Applications of Photography", and, besides the reading of eight papers, visits will be made to the Departments of Naval Architecture, Physical Chemistry, and Photography of King's College. The conference will be open to all, no tickets being necessary. Further information can be obtained from Mr. C. J. Duncan, Director, Department of Photography, Medical School, Newcastle upon Tyne 1, or from the honorary conference secretary of the Scientific and Technical Group, Dr. R. S. Schultze, Research Library, Kodak, Ltd., Harrow, Middlesex.

The Edison Swan Electric Co., Ltd. (155 Charing Cross Road, London, W.C.2), has published the third in its series of educational booklets, entitled "Electrons", this latest one being on screened-grid and pentode valves. It surveys the disadvantages of the triode in order to show how, for certain purposes, improvement can be obtained by an additional grid as in the screened-grid or tetrode valve, and by two additional grids as in the pentode. In addition to explanatory circuit diagrams, the booklet contains a specially prepared sectional drawing of the Ediswan Mazda high-slope screened radio-frequency pentode 6*F*1 valve, showing the electrode assembly and full details as to its operating conditions.

The "Bibliography of Articles appearing in Turkish Periodicals, No. 5" (pp. 138. Istanbul: Milli Egitim Basimevi), covering the period October–December 1952, contains some nine hundred entries, arranged according to the Universal Decimal Classification (first two figures only), and alphabetically by authors within each section. Slightly more than half the entries fall under science and applied science or technology. A list of periodicals covered, with the place of publication, and an author index are included, and the explanatory preface is in Turkish and in French.

BRITISH ASSOCIATION MEETING AT OXFORD

SCIENCE AND HUMAN NATURE

By Dr. E. D. ADRIAN, O.M., P.R.S.

PRESIDENTIAL ADDRESS

THREE hundred years ago a scientific society used to meet in Oxford every week in the rooms of Dr. Wilkins of Wadham College. It was the first of its kind in Britain and it had what we should now call an escapist motive. Fifty years before, Francis Bacon had published his great plan for a new road to knowledge, by concerted observation and experiment, and Harvey soon after had made the experiments which proved the circulation of the blood. But then the country had been torn by civil war. It had killed its King and could not see how to reach settled government. Dr. Wilkins had collected a band of scholars of inquiring mind, Boyle, Wren, Willis and others whose names are now part of the history of science, and they met together to take what comfort they could in the new kind of knowledge which could be confirmed by experiment instead of the appeal to authority. "Their first purpose was no more than only the satisfaction of breathing a freer air and of conversing in quiet with one another without being engaged in the passions and madness of that dismal age."

So it was in Oxford that the scientific age was conceived in England, with the conflicting loyalties of the Commonwealth as a background, and I can admit Oxford's claim the more cheerfully because Dr. Wilkins moved to Cambridge and was for a short time Master of Trinity College, just before Isaac Newton came there as a young undergraduate.

When the King came to his own again the temper of opinion changed. There were great prospects ahead. The philosophers moved to London, convinced that their inquiries would lead to material prosperity as well as to deeper knowledge. They founded the Royal Society, and Isaac Newton's "Principia" established the mechanical order of the world. The material progress followed more slowly; but one hundred years after Newton's death it had already begun to affect the lives of half the people in Britain. Scientists, as usual, were in no doubt about the value of what they were doing and they felt it was high time to share their faith and some of their responsibilities.

In 1831, therefore, the British Association was founded for the advancement of science and at the annual meeting our leading scientists assembled in one big town after another to spread the news of this fresh source of knowledge and of material advance; and the Association has gone round ever since on much the same errand, announcing new discoveries and airing controversies before an audience which has grown steadily in size and in its understanding of what the scientists are about.

But now the products of science are everywhere. Knowledge of the material world is constantly growing, and its consequences are of such a spectacular nature that everyone is aware of them: few people now can doubt that the scientist's picture of the world must have some validity if it enables him to deliver such remarkable goods. So it has come about that the advancement of science is in everyone's mind. Why then are we here to-day? What is there left for the British Association to do if it can only preach to the converted?

For scientists it can do a great deal. We are all specialists nowadays, and here we can learn what is happening in fields outside our own; but it is true that these meetings must lack some of the appeal they had when the whole territory of science was so much smaller. Progress is too rapid for the new discoveries to be saved up as a birthday present, and controversies have become too technical to be aired in the market place. Yet there is one very great and worthy task which needs the help of a body like ours which brings scientists and laymen together. The Association must show the layman where the scientific age is leading him. It is by its impact on public opinion that the success of these meetings must be judged.

No meeting of the Association at Oxford could pass without reference to that famous occasion when its impact on public opinion was highest, when it was made quite clear that the pursuit of natural science would mean a painful revision of beliefs as well as a gain of material comfort, when it claimed acceptance for the theory that denied the special creation of mankind.

It was in 1860, the year after the publication of Darwin's book on "The Origin of Species". Bishop Wilberforce was to speak and Huxley was Darwin's champion. The audience was too large for the lecture room and they moved to the long west room of the Museum; but the first paper was dull, it was on "The Intellectual Development of Europe considered with reference to the views of Mr. Darwin", and after an hour of it the audience was restless and wanted something more dramatic. They had it from the Bishop, who spoke with eloquence and wit against the idea that man and the monkey could have a common ancestor. He ended with an ill-conceived joke about Huxley's claim that he was descended from the apes; but he sat down to general acclamation and the fluttering handkerchiefs waved by the ladies. Huxley had a more harshly coloured picture to present: the aim of life was merely to go on living, the road to progress was by the slaughter of the weak and the survival of the strong, and man was cousin to senseless brutes. The scientists were demanding that the search must go on, that the evidence must be followed wherever it led, but until then it had not led to anything quite so bleak.

All this was no doubt implicit in Huxley's speech; but the audience at the British Association is human and what really stirred them was Huxley's grand indignation at the idea of a bishop condescending to such a paltry joke on so high a theme. His scorn forced the excitement to such a pitch that one lady fainted and had to be carried out, and afterwards no one, not even Huxley, could remember exactly what he had said. It did not matter so much, for the chief issue was no longer the origin of species, but whether Bishop Wilberforce had really been guilty of a breach of good manners. But the dispute had been on the scientific plane and the evidence could not be ruled out because it was unpalatable:

within a few years the battle for Darwin's theory was won and it seemed that the discoveries of science had forced the human race to give up beliefs on which it had relied for centuries.

Naturally the change came gradually, bringing discord into a good many families where the rising generation were zealous converts to the new creed. But now the scars are mostly healed. Advancing understanding of what was really at stake has made it possible for both sides to keep their ideals. The theory of evolution has lost its power to arouse passionate resentment or passionate faith.

I have mentioned that meeting for two reasons: because it emphasized that man himself was part of the natural world and because it emphasized also his right, at all events his determination, to go on searching for knowledge, for without his curiosity he would be nothing.

We all know where our curiosity has now landed us: with advances in atomic physics which might be applied to devastate half the world, and if they were so applied would certainly make life in the other half extremely precarious. Our grandfathers here were faced with scientific discoveries which were no laughing matter, for to many of them they spelled the end of all worthy human aims; but we face discoveries which might spell the end of all human aims, worthy or not.

We can regret that atomic bombs are possible without regretting the discoveries that have led to them. Advances in natural science cannot avoid advancing the methods of warfare; they do so when they make armies more healthy as well as when they increase the power of their weapons. But although the strategists have to think mainly of immense explosions and great devastation, it would be a mistake to suppose that these are the only dangers. Even if we can survive them we must face the possibility that repeated atomic explosions will lead to a degree of general radioactivity which no one can tolerate or escape.

The level would not rise rapidly and there is a large margin in hand; but the physicists can estimate the persistent contamination which must follow an atomic explosion of a given magnitude and the biologists can assign limits to the amount of contamination which could be let loose on the world without serious danger to every part of it. When atomic energy is used for supplying power for industry the dangers of contamination are real enough, but due precautions can be taken to avoid them. In a major war they would soon be set aside. Powerful nations who think they could win quickly might accept the risk. A few hundred large bombs would not raise the level of radiation to the point where it would become a general danger, and no doubt a country of small area like ours could be reduced to ashes by a relatively small mass of explosion. Though the ashes would be deadly, the rest of the world might escape them. But a long war between powers well armed with bombs would certainly involve an order of radioactive contamination which would involve us all—victors as well as vanquished.

Arguments that war does not pay will not count much when ideals are threatened. It is true that a war which would probably end in wholesale destruction can appeal only to people who are desperate; but they can be made desperate and that is the end we have to guard against. There are conceivable safeguards, of course; but controls and conventions are not foolproof, and in future whenever the world is split into two opposing groups with large stores of atomic weapons it must face this added risk of catastrophe.

Yet we have surely no right to feel that our predicament is so much worse than that of earlier generations. Our grandfathers could do nothing to ward off the danger which seemed to face their cherished beliefs; but our fate is in our own hands. We are afraid, and rightly, because we cannot trust ourselves to act peaceably, because we know that unless we are ready to give up some of our old loyalties we may be forced into a fight which might end the human race. Our predicament is the inevitable result of our curiosity and of the physical nature of the world we live in; but if we can make our behaviour worthy of our increased knowledge we can live safely. The scientist, therefore, has a double responsibility. He must apply his science to learn as much as possible about the mental and physical causes which make us behave as we do, he must study human nature to prevent its failures; but he cannot wait for the discoveries which might make us act more wisely: he must take us as we are and make it his task at meetings like this to point out that the human race cannot stand more than a few thousand large atomic explosions whether they hit their target or miss it. If we can make this known universally our Association will not have failed in its purpose.

It may be optimistic to think that our dangers would recede if we had a better understanding of human reactions: in fact, if we must continue to make war there is no kind of scientific investigation which might not be used for making it more effective, and there can be no guarantee that discoveries in the field of human conduct would be harmless. A drug or a system of education which would make us all do as we are told, a method of producing radical conversion to a new system of belief, a knowledge of new ways of rousing patriotic ardour, all these might be used with consequences almost as grim as the genetical deterioration in a radioactive world. The psychiatrist who discovers a cure for paranoia may find that he has also revealed a convenient way of producing it.

Our novelists have made us aware of these dangers; but it is some comfort to feel that in this case the increased knowledge could be used for defence as well as attack. We can only be protected from radioactivity by living in caves on uncontaminated food and drink; but an increased knowledge of how the mind can be influenced could certainly forestall many of the influences which might be used for undermining our integrity.

It is certainly true that discoveries relating to our own nature may mean a painful readjustment of our beliefs: that, however, is a fair price for increased understanding and, in fact, our ideas about our own behaviour have already been assailed in such a way that further revelations are unlikely to shock us. There is a fairly close parallel between the impact of the theory of natural selection one hundred years ago and that of Freud's theories on our own generation. The British Association does not come into it, because Freud's evidence was all on the medical side; but his views made the same kind of attack on our pride and met with the same passionate resentment or approval. The theory of unconscious forces moulding our thought has certainly diminished our stature as intelligent beings; yet the parallel still holds, for again we have recovered our equanimity.

We are reconciled to the unconscious, though we may not have digested all the elaborations of psycho-analytic theory. We are no doubt less sure of ourselves, inclined to spare the rod and to put nothing in its place; but, on the whole, Freud has left us with a better understanding of human conduct and we are not down-hearted at finding it less rational then we used to suppose.

Freud would have liked to build up a system based on the physiology of the brain; but he was soon too deeply committed to the psychological side. Pavlov's conception of human behaviour was based on brain physiology and it was less disturbing because it did not go into such uncomfortable detail. It is now perhaps more disturbing than Freud's, because Pavlov's notion of the conditioned reflex has come to dominate one side of the world; but we must not think the less of it because it has been used for justifying a political system foreign to ours. Pavlov and Freud were both scientists of surprising originality. They gave a new impetus to research on human activity; but the fields they explored are still waiting for the next advance to show how much they will yield.

The difficulty is that there are so many fields of inquiry to cover, each with its own limited range of facts and deductions. Freud studied dreams and neuroses and explained them as the product of repressed desires. Pavlov studied learning in animals and explained it in terms of conditioned reflexes. But physiologists ever since Galvani have studied the reactions of nerve fibres and nerve cells, the units of the nervous system, in the hope of explaining what they do in the terms of physics and chemistry. This approach at the lowest level can tell us little about the way in which units are organized; but when we keep to physical and chemical problems we are in the familiar territory of the exact sciences, we know how experiments should be conducted and there are great technical advances at our disposal. It is when we begin to think of organisms rather than molecules that we seem to part company with mechanism.

At this end of the scale, then, our actions are found to depend on the vast mass of cellular material which makes up the nervous system, receiving signals about the outside world from the sense organs and sending out signals to the muscles to produce the complex movements of intelligent behaviour. The nervous signals can be recorded and analysed because they are revealed by brief electrical effects, and we are rapidly gaining a fairly clear picture of the energy transformations which make them possible (and incidentally we should never have gone so far if there had been no radioactive sodium and potassium for tracing ionic movements).

The sensory inflow brings information about the events taking place outside us and progress reports to show how successfully we are dealing with them; signals from the muscles are needed to adjust the simplest movements and we are handicapped if we cannot hear what we are saying and cannot watch our step. But the great central mass of nerve cells has to fabricate a radically different pattern of messages to send out to the muscles and it is a pattern which depends on past as well as present information, on what happened to us a year ago as well as on what is happening now. Unfortunately, it is a great deal easier to study the immediate reactions of the nervous system than the more persistent changes which alter its habits and give us our memories. We know next to nothing about the plasticity which is the most important feature of the brain and that is the next hurdle for the biophysicists and biochemists.

But we do know that the cells of the brain do not behave as passive agents for conducting and combining the signals that reach them. As long as we are awake many of them are in continuous rhythmic activity. The system has its own reserves of energy and is unstable; at all events, it is so constituted that a slight disturbance of equilibrium will start up a cycle of discharge and recovery repeated many times a second and extended through much of its substance. It is no great surprise to find that we are driven to our daily activity by a cell system of this kind with energy to be dissipated; but we are now learning something about the interplay of the different parts of the system. It is found, for example, that a relatively small collection of cells at the base of the brain has a profound effect on the general level of activity, so that we are aroused when it is stimulated and fall into coma if it is injured. We can see too how the chief focus of disturbance shifts from one region of the cerebrum to another when we transfer our attention. In fact, we are beginning to trace a closer connexion between what is going on in the different parts of the brain and what we happen to be doing from moment to moment. For what it is worth, we can see a physical reason for our restless lives and our insatiable curiosity.

One may well feel that the most detailed knowledge of brain physiology will never help us much in our efforts to live peaceably; but it would be rash to prophesy. Certainly there are people now who lead more placid, if perhaps less useful lives, because their anxieties have been diminished by leucotomy, an operation on the frontal lobes of the brain; and long before the advent of leucotomy we had become accustomed to adjusting the activity of our nervous system by chemical agents. Tea and coffee, alcohol and tobacco are the stimulants and sedatives of the pre-scientific age and now, to quote the preacher, there is no end to the works of the apothecary, and we seem to be much less afraid of using the confections he gives us to take away our pains.

Only the writers of science fiction would suggest a future in which the problems of civilization will be dealt with by tampering with the brains of some or all of mankind. It will help us a little to settle our differences if we have the means of ensuring a clear head and an even temper after a long journey and a resetting of the daily rhythm; but clearly we must look beyond physiology for an adequate picture of the human brain in action. Though it should start at the molecular or the cellular level, the evidence for it must include the activities of the finished product. We must find out what human behaviour is like before we try to explain how it is produced.

We do know, of course, an immense deal about human behaviour, from our own experience and from the accumulated wisdom of the past; but it is only in recent times that we have tried to check our knowledge by the methods of natural science. The development of physical science dates from the time when direct observation and experiment were accepted as better guides than the principles which had seemed self-evident to the philosophers and the schoolmen. They were wise enough, but it was found that they could be mistaken. So now we can look to the many branches of social science to make a dispassionate study of what actually happens in our society without regard to what might be expected to happen if we are to believe all we have been taught.

The picture of human behaviour which the social scientist has to draw is of a system in which the units are men and women rather than cells or molecules. It is true that one man behaves very differently from another—it is part of our political creed that they must be allowed, within limits, to differ as much as they like. But, although we can insist that the units are not all alike, the general principles which determine their behaviour ought to stand out when we deal with millions rather than individuals.

There is, in fact, one branch of social science which can adopt this plan without difficulty. This is the science of economics, which considers only the human activities of producing and consuming, and studies the way in which these activities are to be balanced. When the balance is lost, credit and currencies fail and we may blame the economists for the plight we are in; but the status of their science is unquestioned, and no one would dream of saying that our complex civilization could have done as well without them.

It must be admitted, however, that the strength of economic theories rests very largely on the fact that they can be worked out with very little regard to human nature. Men must be assumed to be capable of trading with one another and they must have a variety of skills and needs and possessions; but that is all, or nearly all, that the economist has to consider. Few of the many branches of social science can proceed on such a simple basis, and it is because of this that the subject as a whole has still to win full recognition in Britain where the science of economics is so firmly established.

Theories describing or explaining other kinds of social activity are nothing new, they existed long before the theories of economics; but the economists have had the figures to check their conclusions and until recently the sociologists have had little but their own philosophy and their own reading of history. Even Durkheim, who broke away from the philosophic tradition, could only point the way to a truly objective study of human society. Now the position is quite different. A century and a half ago it had only just been decided that the population of Britain was on the increase. Many had thought that might be so, but there were no figures to show whether they were right or wrong. Now there are all the modern techniques for fact finding, the questionnaires, the punched cards, the sorting machines and the statistical methods. It is far easier now to deal with large groups, and the psychologists have far more knowledge of the irrational factors which can sway the smaller groups as well as the family and the individual. The stage seems to be set for the new development, and it might well be the most important scientific development of this century. Why are we still so reluctant to think well of it?

The answer, I suppose, is that we are not yet convinced that the kind of observations that the social scientist can make will be sufficiently objective and sufficiently precise. Those of us who work in laboratories have a far easier task in selecting what we should observe, yet we know how difficult it is for us to select and observe fairly. We have to school ourselves not to reject the exceptional result as worthless when it does not fit a cherished theory: we have to be continually aware of our own fallibility even though we have all the figures and controls to keep us straight. We are loth to believe that the social scientists are more open-minded than we are, and the material they have to deal with seems to need an almost superhuman open-mindedness combined with an almost superhuman power of selection, of seeing the wood as well as the trees in it. We feel that we should be lost in such a wood where everyone must feel the bias of his own upbringing and social ties, where there is so much that cannot be measured and may or may not be relevant and where there is rarely an opportunity of checking the conclusions by experiment.

Our distrust is probably intensified by the layman's tendency to speak of experiments in the social field as though they were comparable with the experiments which obey all the exacting rules of the laboratory. There we can at least hope to proceed by changing one factor at a time. The social scientist would be the last to cherish any such hope: his whole training warns him of the complexity of any situation where human beings are involved. But many people seem to think that if something in the social field is done in a new and usually more expensive way we have only to call it an experiment to justify the conclusions we wish to draw. Certainly we must try new methods and hope to find out why they succeed or fail; but although a new way to check juvenile delinquency or develop a housing estate may give the most favourable results, it is very seldom an experiment from which one can infer the precise factors that have made for its success. A change in the birth-rate, a wet summer or a newspaper campaign are the kind of disturbing element which would be too obvious to mention were it not that everyone who has worked in a laboratory must be aware of having overlooked disturbing factors which should have been just as obvious. We were lucky if our control experiments saved us from exposing our folly; but controls are far easier in the laboratory than in the world outside.

This is a minor grudge. If we harbour it we shall be visiting the sins of the enthusiast on the very people who exist to keep them in check, and we must surely welcome any new branch of study which tries to substitute the methods of natural science for unchecked speculation. It is very easy for us to forget our own rules when we allow our feelings to take charge, to say that a result was too obvious to be worth the proof if we happen to like it, and if we dislike it to say that statistics can be made to prove anything. Perhaps we have forgotten how much we distrusted some new development near our own field of science because it was unfamiliar and because we thought its backers claimed too much for it. We ought to remember that the now flourishing science of biochemistry was once distrusted by chemists as well as physiologists. It is human nature for the guild of natural scientists to delay admitting a new member until he has paid his dues and satisfied the examiners of his competence in the craft.

At present there are many kinds of investigation grouped under the umbrella of social science: the groups seem to have little in common and few of them can put their results into figures; but I think all of us, scientists and laymen alike, are becoming more aware of the value of social investigation and of the degree of certainty it can bring. We may have distrusted the army psychologists who classed us by our aptitudes, we may have read the Kinsey report from unscientific motives and we may continue to allow the accident-prone to drive their motor-cars. We can see none the less that there are facts to be found out about our usefulness in society, about our relations to one another and about the risks we take. We can see too that the search for these facts can be

conducted on reasonably scientific lines. It is too early to be cautious in spending money on large-scale investigations. They are bound to be costly, and those of the social scientist deserve not only the support of national and international funds. There is this kind of support for the subject already; but it is too important a plant to be left in the hot-house atmosphere of research institutes and Unesco teams. It deserves to be in full contact with all the conservative and academic people in universities, the lawyers and historians as well as the economists, biologists and statisticians. There must be more social scientists in our universities so that the rising generation can see what they are like.

I have put in this plea for a subject about which I know so little because it seems to be developing more rapidly in other countries, particularly in the United States. We are handicapped, no doubt, by smaller resources and perhaps by the remains of a national temperament which has made us prefer to work by ourselves and not as members of a large team. We ought not to expect too much. Social scientists, like economists, may be able to foretell the consequences which are likely to follow in a particular situation; but the statesman who goes to consult them may come away with little to comfort him and may turn to the quack doctor in the next street. We may find out a great deal about the tensions which lead to war without seeing the way to keep ourselves clear of it.

But human beings, when we consider them as material for the biologist, are not to be thought of as incapable of improvement. Other kinds of animal have been found to possess unexpected power of communicating with one another; but we are the one kind endowed with a brain which gives us the power of communicating by putting our impressions into words and appreciating the meaning of the words we hear. Speech would be little use to us unless we could remember what it meant; but memory, the ability to learn, is a property of the simplest kinds of nervous system. We alone possess a nervous system which gives us the power to order our ideas in words. We alone have this way of thought which allows us to compare a new problem with an old one.

With this unique equipment for thinking and communicating we can form our habits not only from what happens to us personally but from what happens to our fellows and from what has happened to countless generations in the past; and although the storage capacity of a single human brain is limited, we have learnt to make permanent records of what has occurred, in visible symbols, so that what cannot be remembered can be found in a book. In this scientific era our store of knowledge is growing so fast that we shall soon need new ways to keep it available. Books have done duty for a thousand years and we should be sorry to lose them; but we can change our habits rapidly and it is already old-fashioned to write a letter with a pen.

This increasing background of experience has meant that we are constantly acquiring new habits and new ways of thought. It does not take us very long to see the way round old quarrels. Darwin and Freud no longer trouble us. We are no doubt born with brains like those of our remote ancestors and when we are grown up we have no more native intelligence than they had; but our brains must have been so modified by what we have learnt that they are physically and chemically different, better adapted for the complex social life of our time. We have more knowledge at our disposal. If all goes well with our training, the brains we have ought to be more civilized than those of our fathers and those of the next generation more civilized than ours.

I have claimed that the scientific investigation of mankind can help the process of civilization by finding the weak points in our equipment and suggesting remedies; but these scientific activities will play only a limited part in the development of human society in the scientific age. The power we have acquired over the forces of Nature has made it possible to increase our mental training as well as our standard of comfort. Of the two or three thousand million people in the world, perhaps not more than five million are receiving a full university training, though no doubt more are trained in a narrow technology. Yet the number has risen steeply in spite of wars, perhaps even because of them, and it continues to rise. In the United Kingdom we have 85,000 students at our universities, about 1 in 30 of the whole age-group, and that may be all we should contemplate with our present system. A few years ago, however, it was only 1 in 60, and there must be many parts of the world where the university, as we know it, is only now beginning to play its part in civilizing the most intelligent citizens. This could never have happened without all the scientific inventions which have been blamed for our troubles, the improved transport, the cheap printing, the electricity and the internal combustion engine. And a university training would have been far less civilizing if it had never left the old authoritarian pattern which roused Huxley to speak in Oxford nearly one hundred years ago.

University students, however intelligent, are not usually considered to be the most peaceful members of the community. They have been more welcome in small country towns than in the capitals where they can join revolts against the government of the day, and they tend wherever they are to be critical of those in authority. Long may students remain so. If they were not, if they believed all they read in an officially inspired press, or even what they were taught by unrestrained professors of the greatest integrity, there would be little chance of their learning how to use their knowledge for solving the new problems of our time. The plodding methods of the laboratory and the card index must be there to check their enthusiasm and to show them how the problems have come about. Even if they get no help from that, it is something to know that there are many more people in the world to-day with brains better trained to deal with their environment by learning how its problems have been dealt with in the past.

The British Association is concerned with the advance of natural science. It began when we had little control over the forces of Nature, and we have now so much that we might soon become able to destroy two-thirds of the world by pressing a button. Yet the control which has been achieved by science has made it possible for us to improve our own natures by more education in the arts of civilized life. We may perhaps improve ourselves more rapidly if we can gain more insight into human behaviour. That is something which the Association can encourage; but it is only a small part of what it must do. It must not cease to encourage every kind of scientific inquiry, for it is human nature to inquire, to learn by experience, and to profit by what it finds out.

SUMMARIES OF ADDRESSES OF PRESIDENTS OF SECTIONS

RECENT DEVELOPMENTS IN NUCLEAR PHYSICS

THE post-war development of accelerators for atomic particles has enabled a new high-energy branch of nuclear physics to be developed, the main objective of which is the study of the forces between nucleons and their relation to mesons and the meson fields. This forms the subject of the presidential address to Section A (Mathematics and Physics) by Sir John Cockcroft.

In Britain we have brought into operation within the past year, for the study of this field of physics, a billion-volt proton synchrotron, a 400-million volt cyclotron and a 330-million volt electron synchrotron, while the Harwell cyclotron has produced protons and neutrons of energies up to 180 million volts. In the United States, in addition to machines of these types, proton synchrotrons of 2 and 6 billion volts are now operating.

Experiments on the scattering of protons by protons and protons by neutrons have demonstrated the exchange nature of the nuclear forces. The scattering of protons in succession from carbon and hydrogen targets have shown that protons after scattering have about 80 per cent of their spin axes pointing in one direction, that is, they become polarized. This results in four times as many being scattered to the left as compared to the right from the second target. This demonstrates another characteristic of nuclear forces—the very strong interaction between the spin of the nucleon and its orbital motion—which produces a non-central force.

The high-energy collision of nucleons produce π-mesons at nuclear energies greater than 200 million volts. At energies of a billion volts pairs of heavier mesons have been created. One of them is the excited proton first discovered by Rochester and Butler, originally called the V^0 meson. The other is a θ^0 meson, which decays into two π-mesons.

These and other mesons are very closely connected with nuclear forces. In nucleon collisions of medium energy, momentum is transferred through the intermediary of the 'meson cloud' associated with a nucleon. When the collisions are energetic enough, the π-mesons materialize, live for a hundred-millionth of a second and decay. In still closer encounters the heavy meson must play a similar part in nuclear forces, giving rise to shorter-range components of the force.

Mesons are now produced in such large numbers by the accelerators that they can be used for experiments on the properties of the meson. Thus the π-meson has been shown to have zero spin—like an alpha-particle or light quantum. It can form a compound nucleus with a nucleon of a very high degree of excitation. It can also form mesic atoms in which the meson plays a similar part to an electron in the atom, and mesic X-rays are produced in orbital transitions.

The address concludes with a reference to the dangers and peaceful potentialities of these powerful nuclear forces.

NEW IDEAS IN CHEMISTRY

SIR JOHN LENNARD-JONES, president of Section B (Chemistry), remarks in his presidential address to that Section that when the British Association last met in Oxford in 1926 physicists pictured electrons in atoms as rotating in orbits around a central nucleus like a solar system. Though this view had great success in clarifying the behaviour of atoms under the influence of light, and in providing a theoretical basis for the periodic table of elements, it had little influence on chemistry, for it did not prove possible to extend the mode of description to molecules. It was the wave theory of matter which opened the way. This provided a novel way of describing the states of electrons in atoms and molecules and a new technique for calculating their stationary states.

In the new theory two ideas were found to have an important place. The first one was that electrons are indistinguishable from one another, so that an interchange of any two does not produce an observable change. The second one was that electrons in atoms and molecules obey strictly the rule that no two take the same role at the same time. Electrons are said to have the 'property of exclusion'. No theoretical proof has been given of this—it is injected into current theories as a working rule and is justified only by its success in predicting the properties of matter.

These two ideas, together with the wave description of electrons, have proved of great importance in explaining the properties of molecules; in fact, it may be said that a unification of atomic physics and chemistry has thus been brought about. The property of exclusion appears to be more powerful than the forces of repulsion or attraction such as exist between electrical charges of like or unlike kind. These latter are of short range and cease to be effective beyond lengths of atomic dimensions; but the 'awareness' which one electron seems to have of another of the same kind of spin seems to extend throughout a molecule, however large it may be. Electrons can thus influence each other over distances many times greater than the sizes of the atoms which a molecule may contain.

The property of exclusion implies that electrons of the same spin avoid each other as though there were a powerful force of repulsion between them. This plays a vital part in fixing the shapes of molecules and, in particular, in producing the directed valencies of carbon. The occurrence of 'lone pairs' of electrons and the asymmetric distribution of charge in molecules can be traced back to the same property. Thus this seems to be the primary cause of electron-rich regions and the agent impelling chemical reactions to go.

One of the most interesting and profitable applications of the new ideas has been to the structure of conjugated molecules. Many of their characteristic properties, such as alternating polarity and the shifts of electrons under the influence of substituents, can now be understood in principle in terms of the same concepts used for saturated molecules.

THE RELATIONSHIP OF PALÆONTOLOGY TO STRATIGRAPHY

IN his presidential address to Section C (Geology), Dr. C. J. Stubblefield points out that Oxford is a shrine of British palæontology, for from Oxford came the first printed illustrations of British fossils. These appeared in the "Natural History of Oxfordshire", published in 1677, from the work of the first curator of the Ashmolean Museum, Robert Plot. Oxfordshire has other claims for pilgrimage. It contains the birthplace of William Smith; a man whose discovery, that the fossils contained in rocks could be the means of identifying strata, gave a new approach to stratigraphy. Furthermore, the richly fossiliferous Jurassic rocks of which the county is composed have here and elsewhere, by their fossils, provided the key to many basic principles of stratigraphy.

The stratigrapher produces geological maps showing the identification and disposition of the strata in available areas; he describes the geology of the earth's crust. The palæontologist works to ensure accurately determined fossils, with knowledge of their conditions of life, structure, relationships and distribution.

At the time of William Smith's discovery, palæontology was very young; but it was nurtured by three distinguished French biologists, Lamarck, Cuvier and Brongniart. The first two noticed in mapping and tracing upwards the rock succession in the Paris basin that the fossil Mollusca became progressively more like living forms; this observation eventually became perpetuated in the formational names Eocene, Oligocene, Miocene and Pliocene. On a broader basis the changing pattern of life revealed by what is now known to be a quarter or less of the history of the earth's crust is also expressed in J. Phillips's terms Palæozoic, Mesozoic and Cainozoic.

The most striking aspect of the application of palæontology to stratigraphy has been in the classification of the stratal column into successively smaller divisions and in correlating rocks found in different parts of the world.

Palæontology, coupled with an appreciation of lithological changes in contemporaneous deposits, played a prominent part in the establishment of the Devonian or Old Red Sandstone System; in the founding of the Ordovician System the faunas were also an important consideration. Stratal divisions known as stages were formulated by d'Orbigny entirely from palæontological studies, and, in revised and extended form, are useful standards of comparison for regional correlation particularly when considered as unit sequences of zones, that is, of rocks containing successive assemblages of fossils. Such sequences of zones have also helped stratigraphers to find evidence of stratal gaps, and of folding and faulting.

While a geological map is the published outcome of a particular local geological study, in Britain it is now regrettably rare to find, in the accompanying account, pictures of the fossils on which critical age determinations are based. On the other hand, the typical large-scale geological map is required to show the distribution of the different lithological units for several purposes, some non-geological. Though palæontology is used for ensuring accuracy in the local correlations, the mapped divisions should not be too subjectively palæontological. Nevertheless, when such maps are combined for reduction to smaller scales, palæontological data are appreciated as being vital for regional correlation of the rock units.

ARCHAEOPTERYX AND EVOLUTION

IN his presidential address to Section D (Zoology), Sir Gavin de Beer states that the specimen of *Archaeopteryx* preserved in the British Museum (Natural History) has been subjected to a complete re-investigation with the help of modern methods. Making use of the fact that fossil bone shows fluorescence under ultra-violet light whereas the matrix does not, the sternum has been discovered and its bony nature confirmed by X-rays. It is flat and accords with all the other features of the fossil to show that in life it was incapable of active flapping flight but glided from branch to branch of trees. The endocranial cast of the brain has been studied, and Dr. Tilly Edinger's surmises have been confirmed. The cerebral hemispheres were smooth, elongated, and narrow. The cerebellum was small and situated behind the mid-brain, instead of overlapping it from behind and pressing it down to a more ventral level as in modern birds. For the purposes of its limited powers of flight *Archaeopteryx* did not require a high degree of cerebellar co-ordination. Portions of additional vertebræ have been found, confirming that the articulation between their centra was simple.

It has long been realized that *Archaeopteryx* presents a beautifully intermediate condition between reptiles and birds. In principle, an organism intermediate between two groups might be intermediate in structure in all or many of its parts; or it might be composed of a number of structures completely characteristic of one group, a number of other structures equally characteristic of the other group, and few or no features intermediate in structure at all. It is quite clear that the transition from reptiles to birds exemplified by *Archaeopteryx* conforms to the latter alternative, for *Archaeopteryx* is a mosaic of typical reptilian and typical avine characters. The reptilian characters are: the long tail of twenty free vertebræ, the simple articulation between the vertebral centra, the short sacrum involving six vertebræ, the separate metacarpal bones and the presence of claws on all digits of the hand, the separate metatarsal bones, the simple ribs and gastralia, the simple brain with elongated narrow cerebral hemispheres and small cerebellum behind the optic lobes. The avine characters of *Archaeopteryx* are: the feathers identical in structure with those of modern birds, the arrangement of the feathers on the arm identical with that in modern birds, the fusion of the clavicles to form the furcula, the backwardly projecting pubes, and the opposable hallux of the foot.

The transition from reptiles to birds is therefore regarded as providing an example of a mode of evolution termed mosaic evolution, and the question arises whether this mode is also found in the transitions between other classes of vertebrates. The structure of the Ichthyostegalia suggests that this was in fact the case in the evolution of amphibia from fish, and *Seymouria* provides evidence of the same thing in the evolution of reptiles from amphibia. The transition from reptiles to mammals is more complicated to follow, largely because the conventional definition of mammals as vertebrates possessing hair and a squamosal-dentary articulation of the jaws has led to the retention within the reptilian class of

most of the stages of the conversion of reptiles into mammals. Nevertheless, it is extremely probable from the evidence furnished by the ictidosaurs and by the monotremes that the mosaic mode of evolution applied there also.

The emergence of each of the classes of living vertebrates has been characterized by the acquisition of key-characters which have enabled the organisms to become adapted to and radiate widely in an ecological medium previously denied to them: land-and-water, dry land, air. The break-through into the new medium has been made possible by a change in a very small number of pieces of the mosaic, the other pieces remaining as they were for a considerable time. The significance and wide application of the mosaic mode of evolution was clearly recognized by D. M. S. Watson, who provided irrefutable evidence from *Seymouria* in its support, for which reason it is proposed to refer to it as Watson's Principle.

THE COAST AND THE GEOGRAPHER

IN his presidential address to Section E (Geography), Prof. J. A. Steers points out that the geographer has many, but by no means exclusive, interests in the coast. The borderline between land and sea at any one moment of time may seem relatively stable. But changes, both vertical and horizontal, are constantly going on, and those due to erosion and deposition are clearly noticeable in the course of a few years—and sometimes much less. Vertical changes are measurable locally in decades, and in the period since the beginning of the Ice Age they have been profound.

Vegetation, especially on low coasts, can bring about impressive changes in even a few years, and there is much room for experimental work in this field.

The still wider question of the primary origin of coasts is geological rather than geographical; but the study of off-shore contours and evidence of recent movements of a vertical nature, in so far as they affect an 'original' coastline, are of great geographical interest. Apart from physiographical implications, there are many others which concern the geographer. Not least among these is the general picture of the use of the coast by man—ports, industry, dwellings, holidays, etc. The details of planning are scarcely his direct concern; but in presenting an overall view the geographer by his training in the appreciation of regions ought to be able to contribute something of importance.

The geographer can make valuable observations on the factors—waves, winds, tides, etc.—acting on a coast, and since he is probably working on a problem from a purely personal and scientific point of view he is not likely to be concerned only with short-term factors. Hence his contribution to morphology and other aspects of the coast is of use to students in general as well as to engineers.

But when all is said and done, the understanding of the coast is by no means the province of any one group of workers. The more there can be active and friendly collaboration between engineers, geologists, ecologists, and geographers, the better. To achieve this end, there is no need for any very precise organization.

Geographers have great scope for their own particular interests, and the historian or historical geographer has much to give in this respect. There are many examples in Great Britain, and especially around the Mediterranean and North Seas, where the changes affecting ports and harbours and the growth of deltas need the double approach that a geographer trained in both the historical and physical branches of his subject can make. A great deal of the literature at present dealing with such matters minimizes or even overlooks the significance of this double approach. Moreover, there may well be a practical lesson to be learned from such studies. None, for example, would ignore the long history of change wrought by storm and waves along the East Anglian coast in considering new defence or harbour works.

In tropical waters, too, there is plenty of work for the geographer. Much of the significance of coral reefs, of the sand formations resting in them, and of beach-rock formation has yet to be learned. In this connexion, too, co-operation with a biologist will be more than worth while.

Many of the problems with which the geographer is concerned on a coast may be partly investigated in laboratories in which models of the coast are built. These, however, are expensive and not likely to be made unless valuable land or property is affected. Nevertheless, whenever or wherever it is possible for laboratory experiments to be made, full advantage should be taken of them.

THE CHANGING STRUCTURE OF THE BRITISH ECONOMY

THE development of an economy is a process of adjustment to changing technology and changing quantities and distributions of materials and skills. The economic structure at any moment reflects only imperfectly the needs of that moment, since structure changes slowly, and only in periods of less rapid change are the ideal and actual structures likely to be similar. The main elements of structure are the patterns of employment and activity, of export and import, and of consumption.

In his presidential address to Section F (Economics), Prof. E. A. G. Robinson points out that these patterns have changed greatly in the United Kingdom during the past two and a half centuries, when their measurement has been reasonably possible. When Gregory King first estimated many of the relevant statistics in 1688, the population of the United Kingdom was about 7·4 millions. Its retained imports were equal to about 5½ per cent of national income; exports were primarily manufactures of indigenous materials; about two-thirds of all man-power was engaged in agriculture, and England was still a net exporter of agricultural produce.

By 1820, the proportion of employment in agriculture had fallen to about 35 per cent; the import ratio had risen to about 12 per cent; manufactures formed about 90 per cent of all exports, and textile manufactures 67 per cent; coal formed about 1 per cent of total exports. Raw material imports were now about 60 per cent of retained imports, of which textile materials accounted for about 24 per cent.

This process of specialization, of dependence on imported materials and on exports of textiles took a more extreme form as the century went on. By 1870 the import ratio had risen to about 28 per cent (its peak was about 33 per cent in the 1880's). The proportion of retained imports represented by food

had risen to 35 per cent (of which grain was 9 per cent); but we probably provided three-quarters of our food from home agriculture. Textile exports were still the main source of payment for imports, representing 56 per cent of the whole; exports of metals and metal manufactures were beginning to grow and now formed 21 per cent of the whole.

By 1913 the import ratio was back to 28 per cent; with growing population (it was now about six times that of 1688) we had become dependent to the extent of about 55 per cent of our food consumption on imported food, which now formed about 40 per cent of retained imports. At the same time, we were much more dependent on imported materials; home supplies of wool had covered 50 per cent of consumption in 1860; they covered only 16 per cent by 1913. Textile exports were now 34 per cent of total exports; metal and engineering exports had risen to 27 per cent.

Some of these trends continued through the inter-war years. But the import ratio declined, and by 1937 was 21 per cent, partly as a result of lower import prices, but chiefly as a result of balance-of-payments difficulties. The reliance on imported food increased and imports probably provided 65 per cent of food consumption in the years before 1939; but by 1951 this had been reduced to about 50 per cent. Agriculture, which had given employment to 14 per cent of the working population of Britain in 1870 and 8 per cent in 1913, was now down to about 5½ per cent. Textile exports declined greatly; by 1937 they were 24 per cent of the whole, and by 1951 only 19 per cent; the share of metals and engineering exports rose to 35 per cent in 1937 and to 49 per cent in 1951.

It is interesting to contrast the structures of the United Kingdom and of Western Germany. They have almost identical populations, very similar areas, but very different structures. In 1953 the United Kingdom import ratio was 26 per cent, that of Western Germany about 16 per cent. Western Germany maintains an industrial production about two-thirds as great as that of the United Kingdom on raw material imports about one-third as great. It is dependent on imports for only about one-fifth of its food consumption. Each country has much to learn from the other.

It may be difficult for the United Kingdom to continue to find markets for exports on a scale sufficient to maintain its existing import ratio. The high degree of specialization of the second half of the nineteenth century was based on a degree of technical leadership which we cannot hope to recover, and on obstacles to the dissemination of scientific and technical knowledge which, once they have disappeared, cannot be recreated. There is probably less technical advantage now from a high degree of specialization and exchange. The United Kingdom's advantage lay also in the fact that everywhere the terms of trade between primary production and manufacture were very favourable to the latter; we were increasing our imports of primary products from countries, particularly in North America, where there were very considerable gains from moving out of primary production. Circumstances may thus demand considerable change in the United Kingdom's structure. But if there is reluctance to modify the structure, the consequences may be balance-of-payments difficulties which can only be remedied by measures that diminish imports by diminishing activity and employment.

EFFECTS OF NEW MATERIALS ON ENGINEERING PROGRESS

THE dependence of engineering progress on improvements in the existing materials of construction and on the discovery and economic development of new ones forms the subject of Dr. Willis Jackson's presidential address to Section G (Engineering).

Choosing his examples mainly from electrical engineering, he deals first with the insulation of high-voltage power cables and submarine cables. In the former, impregnated lapped paper, introduced by Ferranti in 1898, remains the only form of dielectric structure which can be seriously considered for the highest transmission voltages, notwithstanding the wide range of new synthetic materials which have since become available. From some points of view this may appear to suggest too conservative an attitude on the part of the cable manufacturers; but it can be more properly regarded as a tribute to their ingenuity in overcoming the limitations of the constituent materials, paper and oil, and in introducing new techniques of construction, which have proved adequate to meet the increasingly severe operating requirements. In submarine cables, on the other hand, the previously well-established gutta percha insulation has now been displaced by polyethylene (polythene). The material emerged from the research stage just in time to play a vital part in our early war-time radar installations as the dielectric of the high-frequency cables used for interconnecting the transmitter and aerial systems. Stocks of polyethylene-insulated submarine cables were built up later during the War in preparation for the invasion of the Continent, and the trans-Atlantic telephone cable incorporating submerged repeaters, soon to be embarked upon, is to be made of the same material.

Speaking next of the effect which the development of the low-carbon silicon steels has had on the performance of power transformers, Dr. Willis Jackson explains how the marked crystal orientation which can be produced in silicon steel sheet by appropriate cold-rolling and annealing treatments has made it possible to take advantage of the directional properties exhibited by single crystals of ferromagnetic materials. A more spectacular advance has occurred in magnetic materials for telecommunication applications arising from the introduction of the nickel–iron alloys and of powder-core technique and, more recently, from the war-time development of the ferrites, a range of non-conducting materials derived by replacing one of the iron atoms of Fe_3O_4 by atoms of other elements such as nickel, zinc, manganese, etc.

As an illustration of the way in which the discovery, and recognition of the potentialities, of some special property of a material may lead to the development of a new engineering technique, Dr. Willis Jackson describes the evolution of the germanium crystal triode, the transistor, an amplifying device which can perform many of the functions of the thermionic triode valve with the advantages over it of being simpler in construction, much smaller in size and not requiring a heated electrode as its source of charge carriers. Many difficulties have had to be overcome in the extraction and extreme purification of germanium; but the new device has a wide sphere of application in computers, guided missiles and telecommunications equipment generally.

The conversion of the nuclear energy of uranium into electrical energy affords another example of this

type of development. The practicability of this conversion is dependent on the use of other materials also possessing special properties, though of a different kind, which have led to the rapid rise to engineering importance of such materials as heavy water, liquid sodium and zirconium.

Finally, after referring to the new ceramic materials based on barium titanate, to the emergence of titanium as a structural material and to the recently discovered beneficial effects on the physical properties of certain plastics which result from their irradiation by high-energy particles, Dr. Willis Jackson emphasizes the growing interdependence of progress in chemistry, physics, metallurgy and engineering.

ARCHÆOLOGY IN THE BRITISH COLONIES

SIR MORTIMER WHEELER'S address to Section H (Archæology) is entitled "Colonial Archæology" and is a plea for the urgent need to safeguard cultural and, in particular, historical and archæological evidence in and relating to British Colonial territories. Sir Mortimer is especially concerned with territories of British East Africa—Zanzibar, Kenya, Uganda and Tanganyika—but he also gives evidence showing that the position is bad in the Somaliland Protectorate and Aden and scarcely less unsatisfactory in West Africa, so that by extrapolation it can be surmised that the conservation of cultural treasures is sadly neglected to a greater or lesser degree throughout all the Colonial territories of the British Commonwealth.

The examples quoted from East Africa make indeed a sorry tale. Sir Mortimer gives chapter and verse of priceless buildings, many of them mosques of unique features, that have been pillaged for one reason or another, often quite recently, and in some cases they have even been deliberately destroyed by public works departments to make way for new roads or to supply building materials. The situation is chaotic in that each Colony has its own regulations with regard to conservation, and even where the laws are comprehensive and sensibly framed, their interpretation or execution is often left to officials with many other pressing duties or to persons with little or no interest in the matter. Now and then the story is relieved by examples of excellent (and timely) work; but these bright spots in the pervading gloom are all too often due to the fortuitous hand of some exceptionally enlightened person who struggles alone amidst apathy.

In July last year a widely attended Conference on African History was held in London under the chairmanship of Prof. C. H. Philips, of the London School of Oriental and African Studies, and from the three-day discussion six resolutions were drafted: the outlines of African history could be reconstructed by the co-operation of historians and archæologists; this implies the adequate preservation of ancient and historical sites, monuments and documents, and the development of museums and public record offices; immediate government action and control is therefore needed in the various territories; ultimately departments of antiquities will need to be set up to plan field-work and publish results; record offices, with archivists to run them, will need to be improved or, in some cases, to be created; and as an immediate step, a school of history and archæology in East Africa needs to be established on the lines of the British schools in Rome, Athens and Ankara. These resolutions have been sympathetically received by the Colonial Office, which is ready to be advised on these points by a committee set up by the British Academy; the committee is at present discussing the matter.

Sir Mortimer is of the opinion that finance is not the prime hindrance. He believes that the foremost need is to introduce an adequate antiquities law for each territory. Then the interpretation of the law must not be left solely to the governors and district commissioners; they must be guided by experts, who will in fact be the staff of a territorial archæological department. Such a department needs as an absolute minimum a director, one or more assistant inspectors, normally of local origin, a skilled local foreman, and a museum-cum-store in the charge of a trained curator. A skeleton staff of this pattern will not be over-expensive, for already many territories are bearing certain charges—for example, museums—often in an ill-organized way. But fundamentally the need is for an awakened appreciation by the general public, particularly those in the territories themselves, of the high priority of these problems. The African must be acclimatized to cultural values as much as to political and social evolution. What Lord Curzon did for India and what the French are already doing in their African Empire must be repeated in the British African territories. Though his address deals for the most part with a sorry record of shortcomings, Sir Mortimer Wheeler believes that the present British Colonial administration is concerned about the situation, and he looks forward to the time when good intentions will be translated into actual deeds.

THE RELIEF OF PAIN

PROF. A. D. MACDONALD, in his presidential address to Section I (Physiology), remarks that the problems of pain were discussed by the Section at St. Andrews during the final day of the 1939 meeting of the British Association. At that time the relief of pain by drugs was largely limited to opiates, though the late Dr. T. F. Todd discussed the value of intrathecal injections of alcohol in the terminal stages of malignant disease of the pelvis. His aim was to block sensation, if possible without destroying the motor pathways.

Since then, because of the many drawbacks to morphine, much research has been devoted to the modification of the morphine molecule and to synthetic substitutes in the hope of reducing the disadvantages of morphine. Much ingenuity has been directed to methods of comparative assay of analgesics; but their study in experimental animals is difficult and probably only of value as a screening measure, to be followed by tests on man in both laboratory and hospital. Many compounds have failed to fulfil their initial promises.

Perhaps the most interesting of the morphine derivatives of recent introduction are lævorphan and dextromethorphan, and of the morphine substitutes pethidine and methadone, both of which may be regarded as stepping-stones to long series of related compounds. As a rule, when a derivative is found to be more powerful as an analgesic, it is more toxic and has other grave disadvantages. Pethidine itself has the support of the Medical Research Council

Committee on Analgesia for Labour and is widely used in combination with nitrous oxide or, better, trichloroethylene. The dithienylbutenylamines are more active than pethidine but inferior to morphine. Methadone is in the morphine class as an analgesic, but is less effective in reducing anxiety and promoting sleep.

Potent analgesics are potential drugs of addiction and are, like morphine, carefully controlled by law. Tolerance and dependence may develop even with pethidine, and the need for a reliable analgesic which is not addiction-producing has still to be met. As a laboratory-worker Prof. Macdonald was fortunate in having, to follow him, Dr. P. O. Wolff, of the World Health Organization, Geneva, to discuss some of the problems of addiction, and Mr. J. Pennybacker, of Oxford, to deal with some of the contributions of neurosurgery to the relief of pain.

RECENT STUDIES IN THE PSYCHOLOGY OF THINKING

THERE is a growing sense among psychologists that the psychology of thinking is not only one of the most important areas of psychology both theoretically and practically, but also that it is an area that can be profitably investigated by scientific methods. Thinking is a complex activity rendered possible only as the result of a long period of evolutionary and individual development, and it depends on the co-operation of favourable organic and environmental conditions. The three major aims of the psychologist are: first, to study in detail the development of thinking from its simplest forms to the most highly developed logical and mathematical thinking; secondly, to study the conditions upon which thinking depends; and thirdly, to throw some light upon the general nature of the processes involved in thinking. The purpose of the presidential address by Prof. L. S. Hearnshaw to Section J (Psychology) is to present a sort of interim report on some of the more recent work and speculations of psychologists in the field of normal psychology.

Among this recent work a very high place must be given to the developmental studies of children's thinking carried out by Piaget in Switzerland. Piaget's recent work is not as yet well known in Great Britain. The importance of Piaget's studies is not merely that they constitute by far the most detailed account of children's thinking from the hour of birth to adolescence that has yet been made; it has much more in the comprehensiveness of their scope and their systematic theoretical organization which links the two poles of biology and logic. His studies of the genesis of mathematical and scientific thinking should be of great interest to scientists.

The work of experimental psychologists, though much more fragmentary than that of Piaget, has thrown some light on the subtlety of the personal, emotional and environmental factors that may influence thinking. Though the results of experiments in this field are still meagre in quantity, they indicate the practicability of an experimental approach which may in the course of time place our intuitive art of thought upon firmer foundations.

The tendency of contemporary psychologists is to regard thinking as a high-level skill, derived and built up, therefore, not, as in older views, from special cognitive elements, but compacted, as all skills must be, of both sensory and motor components. Skills are essentially activities, and skills are learned. The gestalt psychologists rightly emphasized organization as an essential feature of all skills, including thinking; but their further contention that this organization is immediate, unlearned, and unanalysable is much less acceptable. In a series of important experiments with monkeys, Harlow has traced the development of apparently immediate insightful behaviour through the establishment of what he terms "learning sets". Insightful behaviour is an end product, the result of a mature skill gradually acquired by experience, and marked increasingly by flexibility, transfer and generalization.

No theory of thinking as yet comes near comprehending the full range of the phenomena we know as thinking. Thinking cannot be equated with problem solving. An adequate theory must embrace every kind of thinking, normal and pathological. Recent studies suggest, however, that the psychology of thinking is no longer an esoteric study, but a branch of psychology which can be objectively studied, and which joins hands not only with better settled areas of psychology, but also with subjects like biology and logic, which lie beyond its own frontiers.

PLANT GROWTH AND PRODUCTION

IN his presidential address to Section K (Botany), Prof. W. H. Pearsall points out that botanists are faced to-day with many developments arising from new and exciting techniques. These have suggested to many that botany is liable to split up into a great number of highly specialized lines of inquiry. On the contrary, these new methods of inquiry should, from various directions, throw new light on the fundamental botanical problems which centre around the organization and growth of plant cells and tissues. Just as growth is the integration of the plant's activities, so the study of growth will serve to integrate inquiries on different aspects of botany.

If the botanist is thus interested in plant growth as a fundamental process, *per se*, the general public is interested in it because it is the means of producing food and raw materials, of which the world is in danger of being starved. It may be useful, therefore, to look on this latter subject somewhat systematically.

Methods of growth analysis devised by F. G. Gregory and his colleagues show that most plants appear to have similar values for their photosynthetical efficiency in growth. The efficiency of a crop thus depends generally more on climatic variations and on the extent and duration of plant-cover than on the nature of the individual plant. This can be illustrated in various ways, particularly by reference to J. D. Ovington's figures for the annual production of dry matter by various types of planted tree. In natural vegetation, too, dry-weight production seems to fall between similar quantitatively definable limits which bear little relation to the type of plant involved, or to some of the obvious ecological factors. Thus, in terms of annual dry-weight yield, waterlogged swamp-soils may be as productive as drained or normal ones.

It appears that very considerable increases in the production of food or raw materials are possible with more continuous crop-cover and improved methods of land-use; but methods of food collection also merit more attention. The use of animals to con-

centrate proteins is wasteful, especially as the high value of leaf proteins is now established and new methods of isolating and storing them are becoming available. The development of these conventional methods of increasing production may well satisfy human needs for many years.

However, other points of view are now becoming prominent. It is evident that the current methods of agriculture are open to criticism on three theoretical grounds: they absorb only a very small part of the incident sun's energy—usually less than 0·1 per cent; they are subject to all the vagaries of uncontrollable climatic variation; and finally, the yields compare unfavourably with those of modern industrial processes. For these three reasons an unconventional approach to the problems of food production has frequently been suggested, and the possibility of controlled employment of micro-organisms in a photosynthetical unit has been canvassed. A discussion of the use of an alga like *Chlorella* in this connexion reveals the practical difficulties that are involved, though real advances in the future are likely from the use of this type of organism.

What is really being envisaged is the development of controllable systems in which the organism acts as an enzyme complex, such that both rate of reaction and type of product can be strictly determined. The problem is whether a sufficiently high rate of photosynthesis can be maintained to give the very large increase in yields which would be industrially desirable in such a system. Botanists would emphasize the unrealized possibilities for synthesis existing in such autotrophic systems. They will also realize the greatly increased knowledge of cellular organization which must be acquired before such methods become possible.

THE TEACHER IN THE TWENTIETH CENTURY

MR. RONALD GOULD in his presidential address to Section L (Education) remarks that the quality of teachers will always be one of the determinants of the quality of succeeding generations. The characteristics of a teacher of high quality are technical competence; a knowledge of the subject to be taught; the power to communicate knowledge; a broad educational background; and personality (that combination of personal characteristics, difficult to define but easily recognized, which enables him to stimulate and encourage his pupils individually and collectively).

Three conditions, however, must be satisfied if the qualities of the teaching profession are to be improved. First, teachers must realize the need for continuing their education. The training college course should be extended to three years. More adequate attention could then be paid to the theory and practice of education, and higher educational standards achieved. Further, every serving teacher should look to his own education, working out his own philosophy, striving to achieve that maturity of mind which would enable him to sift the wheat from the chaff in current educational thinking and practice. This could be done by organizing more refresher courses, the extension of exchanges with American and Dominion teachers, and the release of experienced teachers from school, for six months or a year, for the purpose of undertaking worthwhile educational investigation. Above all, teachers should read widely and keep abreast of modern thought.

Second, teachers must be assured of considerable freedom in their professional work. Freedom from the fear of arbitrary dismissal is essential: so are civic freedom, freedom from compulsory duties not concerned with the work of the school, and academic freedom. After long and hard struggles, teachers have now attained security of tenure. Civic freedom is not a freedom established by law but has been conceded by local authorities because of constant pressure from teachers. This freedom, however, is still threatened. Freedom from compulsory extraneous duties has but recently been established, since only a short time ago teachers were sometimes appointed to county schools not on the basis of their qualifications as teachers, but because they were prepared to be choir masters, Sunday school superintendents, parish clerks, or to assume some other responsibility in the district. Academic freedom is of enormous importance. Within the limits imposed by law, public opinion and the broad consensus of professional opinion, the teacher should be free to choose both the content of his curriculum and the methods to be used. All these freedoms have been acquired in the past fifty years.

The third condition necessary to establish real quality in the teaching profession is that all concerned with the education system—teachers, local authorities, the Government and parents—should regard themselves as a partnership. There is now real partnership, in spite of some misunderstandings and conflicts as to the speed of advance or the means to be adopted, for all these parties are conscious that they serve the child. This is, however, a recent conception. In the eighteenth century, there were three basic ideas about the provision of popular education: it was a charity, it was a voluntary and not a State effort, and it was under ecclesiastical auspices. Such conditions made partnership with teachers impossible. There was little change even after the establishment of School Boards in 1870. From 1902, however, relationships between the teachers and H.M. inspectors, and between teachers and local authorities, slowly improved. Under the Education Act, 1944, administrative power in education was divided among the Minister of Education, 146 local authorities, hundreds of divisional executives, thousands of managerial and governing bodies and a quarter of a million teachers. Such a dispersal of power was politically sound. Successive Ministers, to their credit, have willingly shared with others powers legally their own, and the establishment of many advisory committees by the Minister is evidence of the voluntary sharing of power and the desire for a real partnership. Parent–teacher co-operation, too, has shown marked improvement.

The future, however, holds some dangerous possibilities—the possible reform of local government and in 1956 the review of the education grant formula. Neither of those should be allowed to affect adversely the freedom of the teacher and existing partnerships.

AGRICULTURE: THE INDUSTRY AND THE SCIENCE

THE art and practice of agriculture advanced very little during the two thousand years prior to 1900, the principal change being the evolution of

a system of farming which combined the Saxon plough with the Roman knowledge of agriculture. But, Dr. R. E. Slade points out in his presidential address to Section M (Agriculture), during the past fifty years there have been great changes. The tractor has replaced the horse; the combine harvester is replacing the reaper and binder and the threshing machine. We have improved the fertility of the land by our knowledge of fertilizers and other mineral requirements. We have supplies of phosphates, potash and nitrogen fertilizers. We have insecticides which protect our crops from practically all insects. We can protect our seeds from fungus diseases and we have selective weed killers by which we can destroy the weeds without affecting the crop. We have developed silage and grass-drying for the preservation of summer crops for the winter. We have applied the advances in medicine to veterinary science and we have got control of most of the ills from which animals suffer. We produce only clean milk, and we have increased the yield of our cows by 20 or 30 per cent. We can keep pigs and poultry under labour-saving intensive conditions without getting into trouble through deficiency diseases.

The agricultural industry in Great Britain comes very much under government control. This control of the industry was designed for war conditions and it has lasted until this year. Some industries were decontrolled almost immediately after the end of the Second World War and were able to reorganize for peace-time production when other nations were unable to flood our market with their goods. While agriculture has been under control, the methods of marketing agricultural produce have remained completely stagnant. Now we have neither the organization nor the physical assets to sell our produce in competition with well-organized imports. Organizations are being improvised; but we sadly lack well-equipped abattoirs, cold-storage plants, bacon factories and milk conversion factories as well as organized markets. The annual gross value of the agricultural produce of Britain is now about £1,000,000,000, so farming is one of our largest industries.

An examination of some examples of the introduction of science into the service of the industry indicates that scientific knowledge and inventions are most rapidly adopted when they are introduced to the industry by well-informed salesmen, backed by scientific advisers. The Milk Marketing Board has had a considerable effect on the development of dairying and has been the intermediary for applying science to the industry.

The Agricultural Research Council under the Lord President of the Council spends about £3,000,000 per annum on research. The Agricultural Improvement Council under the Ministry of Agriculture has experimental husbandry farms, and there is also the Agricultural Advisory Service which covers the country. There are thus three layers each covering all agriculture: (1) research, (2) experimental husbandry, and (3) advisory service. Each layer is in itself doing very fine work and excellently co-ordinated. But there is no vertical drive through the three layers. Perhaps some day the present organization will have added to it vertical as well as horizontal direction, and there will be a freer interchange of personnel between the different layers. Then we may expect to see our scientific discoveries rapidly brought into use on the farms.

PHENOLOGY—THE STUDY OF THE SEASONS

IN an introduction to his presidential address to Section X (Assembly of Corresponding Societies), Dr. C. B. Williams compares the young naturalist in the British Isles with one living in the tropics. In Britain there are books, museums and societies, all ready to help and encourage, and Nature is on the whole benign, so that children can be encouraged to study in the fields. In the tropics, Nature is often malignant and there are so many dangerous animals and plants that children have to be taught to fear until they have the knowledge to study. There are also so few books, museums and societies that many possible naturalists lose their enthusiasm from the lack of companionship in their studies.

The study of phenology—or the sequence of biological events in the changing seasons—is an example of a branch of field natural history, covering both animals and plants, in which for many years most of the work in Britain has been done by amateurs. One of the most remarkable examples of continued amateur effort is the series of observations taken in the village of Hevingham in Norfolk of the first date in each spring of the leafing and flowering of certain trees (hawthorn, oak, ash, etc.), the arrival of certain birds (such as the swallow and cuckoo) and the first appearance of some insects. The observations were started in 1736 by Robert Marsham, were continued by him until his death in 1797, and were carried on by his son until 1810. There was then a gap of twenty-five years; but in 1835 the observations were resumed and have been carried on ever since by different members of the same family. The series covers nearly two hundred and twenty years, with only one relatively short break. In the middle of the past century there was a general spread of interest in the subject, and the Royal Meteorological Society formed a Phenological Committee which issued regular annual reports from 1874 until 1947. All the observations were sent in by amateurs scattered over the country, who reached a maximum of more than six hundred in 1931. Unfortunately, interest then waned and in 1947 the Committee gave up this work.

Observations of this type are of great importance for studying the relation of the dates of natural events to changes in weather, climate and geographical position; and the research scientist and the amateur naturalist should co-operate to put the work on a sound basis.

Unfortunately, the analysis of the records is complicated by many accidental sources of error. Some of these can be avoided by greater care, greater regularity of observation, and an increased number of observers scattered widely over the country. Other errors are more difficult to reduce—such as differences in ease of observation between plants and animals, between birds which sing and those that do not, differences due to variation in the abundance of the animal or plant to be observed, and in the ability and experience of observers. For a proper study of the problem events should be selected to cover the whole year round, without so much emphasis—as in the past—on the return of spring.

An appeal is made by Dr. Williams for a better understanding between the research scientist and the amateur, so that each can appreciate the desires and difficulties of the other.

THE NATIONAL INSTITUTE OF AGRICULTURAL BOTANY: ITS PAST, PRESENT AND FUTURE*

By SIR JOHN RUSSELL, O.B.E., F.R.S.

THE National Institute of Agricultural Botany, Cambridge, was founded in 1919 at the time when scientific plant breeding was first being used for the improvement of agricultural crops; its purpose was to test, multiply and popularize new and desirable varieties as they were produced. With it was incorporated the Seed Testing Station that had been founded two years previously. The work has proved so successful that the original staff of four technical officers has now expanded to fifty-three.

The need for the Institute's work to-day is at least as great as ever it has been: Hunter, Engledow and Bell are still producing new varieties of cereals. Others too are active; during the past twelve months the Institute has received fifty-six new varieties of cereals, more than half of which are already approved or recommended in their own countries. It is a great service to our agricultural community to have these thoroughly tested in Cambridge before they are widely taken up by farmers. Moreover, British agriculture is now in a period of some uncertainty. The clear-cut situation of the Second World War, when calories—in practice, wheat and potatoes—and also milk, were our overmastering needs to be achieved at all costs, no longer exists; nor is the immediate post-war problem of saving dollar imports quite so insistent as it was, especially so far as Canada is concerned. Instead, farmers have a general request to produce all they can. But as against this, farmers are conscious of huge surpluses of wheat and other agricultural products piling up unsaleable in the United States, and many of them fear that if they do go all out for increased production they will simply be creating unsaleable surpluses that will be left on their hands. I do not think they are justified, for the surpluses are mainly local and largely confined to North America; the other great producers, the Argentine, Australia and Europe, produce little more than before the War. If and when the United States reduces its acreage of wheat, the surplus will shrink. The European and Mediterranean buyers of wheat are almost certain to increase their imports as their populations increase and their standard of living rises; some of them have already considerably increased their imports of wheat compared with the pre-war days. So also has Egypt, for the very interesting reason that where wheat will grow so will the valuable long-stapled cotton, and in a recent barter with the U.S.S.R. (February 1952) Egypt obtained in exchange for one acre of cotton as much wheat as would have required three or four acres of land to produce. Taking the long view, I see no reason to fear a continued over-production of wheat any more than I fear a coming shortage for those peoples that can afford to buy it.

If there is some anxiety about the future markets for agricultural produce, there need be none about the British farmers' ability to produce. Some of our soils have been cultivated for a thousand years, and some even for double this period; yet they have suffered neither deterioration nor loss by soil erosion, and the yields of crops have steadily increased and, so far as one can judge, are still steadily increasing. The average yield of wheat in Britain before the Second World War was 18 cwt. per acre; it is now 21·5. Barley has gone up from 16·7 cwt. per acre to 20, and oats from 16·3 to 18. Potatoes and sugar beet also show impressive increases. These values are among the highest in the world. But they do not represent anything like what the fields could produce if only we knew all the secrets. Our present average yield of 21·5 cwt. of wheat per acre is, of course, much exceeded by good farmers, who would commonly expect 30–35 cwt. per acre; but these quantities look puny compared with the yields of well over 3 tons per acre recorded in some of the Institute's trials and the 70 cwt. per acre obtained on a commercial farm in East Anglia quite recently. The average yield of potatoes in Britain, 7·4 tons per acre, and the yield expected by good farmers, 10–12 tons per acre, are put in the shade by the 27 tons per acre obtained in Lincolnshire in 1950. We do not know how these big yields are obtained; but they show clearly that we are nowhere near Nature's limits yet, and if we could only let in a little more light we could hope to get such further knowledge as would enable us considerably to increase our yields. Some good teams of scientific workers at Cambridge, Rothamsted, Oxford and elsewhere are striving to learn more about the growth of crops, and if they are left in peace to get on with the job we may reasonably hope for results, though no one can foretell when they may come.

The achievements since pre-war days have been most impressive. Before the War some 30 per cent of the calories being consumed in Britain were produced; this was the equivalent of feeding 14½ million people. By 1950 the production of calories was the equivalent of feeding 20 million people, an increase of roughly 50 per cent in about twelve years—a really astonishing result. In the meantime, the population had increased, and the new production represented 40 per cent of the nation's need for calories; the 30 per cent of pre-war days is now raised to 40 per cent. But the cost has been heavy. To step up from 30 per cent of our requirements to 40 per cent in 1950, the consumption of fertilizers had more than trebled; the number of tractors increased nearly six times; subsidies for farm operations amounted to £24·37 million; expenditure on the agricultural departments—supervision, advice and other activities of ministry officials—rose from the pre-war £8·9 million to £63·7 million, a sevenfold increase; and the cost of producing the food was such that a subsidy of £246 million was needed to enable it to be sold at the prices actually charged. We could, of course, push up this production of 40 per cent of our requirements to 50 per cent, and

* Substance of an address given at the annual general meeting of Fellows of the National Institute of Agricultural Botany on July 16.

quite serious people have even claimed 100 per cent; it would be an interesting parlour game to try and calculate the cost. One fact is impressive. The subsidy of £246 million was for the 40 per cent of food that we produced; whereas for the 60 per cent that we imported the subsidy was only £164 million; this looks like 50 per cent more food at 30 per cent less cost. Actually it is not as simple as that, as the foods are not the same. But the fact remains that the same foods cost more to produce in Britain than they do in Denmark or Holland. One of our most urgent problems is to reduce this cost of production. Good farmers have long tried to do it, many of them with conspicuous success: agricultural economists who study farmers' accounts report differences up to 100 per cent in the cost of production of the same article on different farms in the same region. This article is not the place to discuss the reasons for that, but one can emphasize that the use of high-quality seed and of improved varieties is one of the surest and least-expensive ways of reducing costs of production.

No country of comparable size stands in need of so wide a range of crop varieties as Great Britain, because no country of comparable size, except perhaps New Zealand, shows so wide a range of soils and climates in such a small space. A horticulturist to whom time and money were no object could probably persuade one and the same variety of a plant to grow in almost any pocket of soil and climate in the country. But the agriculturist is not so placed, and he must grow the varieties best suited to his conditions and requirements. First he must find them. Plant breeding has now become so highly developed that new varieties are constantly being produced, and there is always the chance that one of them may be better on a particular group of farms than any now in existence. The chance cannot be left untested. The National Institute of Agricultural Botany is prepared to examine any promising new variety provided that it is uniform and really new: to study its behaviour at Cambridge and on twelve testing stations in other parts of the country under farming conditions of high and low fertility—an extremely important point. In the case of cereals, the resistance to certain diseases and the power to stand up against lodging are studied. All normal agricultural crops, including the farmer's vegetable crops, the common brassicas, carrots, peas and others, are included in the Institute's purview—though not all the intensive horticultural crops. If the new variety justifies inclusion in the Institute's recommended varieties, the Institute helps it on to the market, multiplying up the few pounds of seed produced by the breeder to the fifty or eighty tons required for the first distribution to the trade; and then, when the seedsman has put out his allocation to his selected farmers so that they can multiply it still further, the Institute has a voluntary inspection scheme under the Seed Production Committee for all recommended varieties to see whether the crop is pure enough to go as seed. So thorough is the inspection that some 30 per cent of the crops are rejected because of weed infestation, diseases or other causes. A recent development, and one which seems to me of great importance, is that the Institute is now prepared to test some of the plant breeder's intermediates which otherwise might be discarded and lost; this has already been done at Seale-Hayne College in Devon, and an extension is planned into Norfolk and Yorkshire in the next twelve months. So the Institute acts as the link that completes the chain joining the plant breeder, the seed distributor and the farmer, and the link is strengthened by the happy relationships that exist between the Institute's staff and the National Agricultural Advisory Service.

I have had occasion to study the workings of this combination in a number of countries, and I am greatly impressed by its efficiency in Britain. Beginning with the plant breeders, we have, of course, long been fortunate. We have long had among us artists in plant breeding—you can use no other word, for they were so obviously guided by intuition and a vision of perfection for which they must always strive, though they might never attain. Such was Rowland Biffen, who fifty years ago gave us some superb wheats beginning with Little Joss—which was on the market ten years after his first crossings, compared with the fifteen or twenty years needed now; he also gave us Yeoman. Then there was E. S. Beaven, that sturdy individualist, who, scorning all State aid, with indomitable courage and persistence carried on single-handed his barley-breeding for years and produced Plumage-Archer; and there was Findlay, with the artist's eye for the potato and the artist's reluctance to divulge his technique, and Donald MacKelvie who bred the Arran potatoes. All these men, unprotected by any copyright or royalty system (such as functions in Holland) gave their productions to the world, gaining but little themselves. Dr. R. N. Salaman has recorded their labours in his very interesting book on the potato. But they are gone, and so far as I know only John Clarke, of Ballycastle, Northern Ireland, remains as a private breeder devoting most of his time to raising new varieties of potatoes. The leading seed firms, of course, maintain their plant breeding activities with results known to all of us.

But plant breeding itself has changed. I shall not discuss here whether it has become a science or a complex craft; but it has certainly steadily become more and more reduced to precise expressions and subjected to critical statistical treatment: tests of significance are replacing the artist's eye, and a staff of technical assistants is needed to cope with the great mass of detailed observations now involved. Happily, an organization of this sort can be built up wherever a good secondary school exists, and we are perhaps no longer completely dependent on that elusive creature the genius—who cannot be produced by any system of education but only discovered and nurtured. So far as can be seen, the future of plant breeding is assured in Britain. It is equally so in France. The services to Western Europeans of the great plant breeders of France—the Vilmorins, Desprez, Blondeau, Tourneur and others—are well known; indeed, France has more private plant breeders than Britain; so also has Holland. The contributions of Sweden, both from the official plant breeding station at Svalov which gave us Star, Victory and its displacer Sun II oats, and from the Weibulls at Landskrona, are equally valuable. Denmark, too, is building up an important export trade in pedigree seeds. It is an interesting fact that the exceptionally wide range of conditions in Britain makes it possible to use with advantage varieties from all these countries and from Belgium; they, however, in their much more restricted conditions, can neither draw from each other nor from the British to anything like the same extent that we can draw from them. We have even been able to use

varieties which in their own country were not specially good: the most notable example of this, of course, is Atle wheat, produced in Sweden by the Weibulls, and discarded because it was too late in ripening; but it is doing remarkably well in Britain, succeeding alike in the Fens and on the thin chalk soils, and is equally popular with millers and with farmers. Yet it might so easily have never survived. Remembering how long the famous Marquis wheat of Canada remained unnoticed among the many plots at Ottawa until Charles Saunders detected it by his inelegant chewing test, one wonders whether there are other plants at present unappreciated on some experimental plots because they are too interesting to throw away but not good enough to carry forward.

Therein, of course, lies one of the great advantages of international collaboration. The Institute at Cambridge has been asked by the Organization for European Economic Co-operation to undertake two important international inquiries: a classification of the various strains of grasses, which will be done in collaboration with Dr. W. Davies, of the Grassland Research Station, Hurley; and the preparation of a scheme for uniform nomenclature and terminology for seeds. The National Institute of Agricultural Botany has also been responsible in conjunction with the French Barley Station at Maule for the preparation of a complete set of descriptions of the more important varieties of barley grown and exchanged throughout Europe. Dr. P. S. Wellington has been asked by the same Organization to conduct an international course on seed testing. Such international activities facilitate discussion and the exchange of information, thus expediting progress with the solution of one's own problems.

The search for improved varieties by plant breeding and selection and the search in the wild places by botanical exploration is going on in many lands, and many interesting and potentially valuable sorts are being produced. But in many countries the work gets but little further. When I was last in India in 1951 seeing with admiration the excellent plant-breeding done at New Delhi, Coimbatore and other centres, I asked as to what proportion of the total acreage is sown with these improved varieties. The answer was very interesting. For sugar cane and cotton the proportion was high. The peasant grows sugar cane for the factory, and delivers it there; from the factory also he receives the seed for the new crop. Nearly 90 per cent of the total area was under improved varieties using selected seed. The same applies to cotton. But for the other crops—the cereals, the millets, and the oil seeds grown for local consumption—the proportion was much less: about 20 per cent in the case of wheat, less for rice (by far the most important food crop in India) and very small for the millets, the pulses and the oil seeds. For these crops there is no effective machinery whereby the improved varieties can get into the peasant's hands; there is no reputable and completely trustworthy seed trade in close touch with the peasants to take over the plant-breeder's small stock, and arrange for its multiplication and distribution to them. A government department has undertaken the task; but retail distribution on a credit basis is not really an appropriate government activity. The same problem arises in Africa. New and better strains of some of the crops have already been produced; but in the absence of a completely reliable seed trade the multiplication and distribution of the seed is impeded. We rather take our seed trade in Britain for granted, and would never doubt a guarantee of one of our great houses: it is difficult for us to realize how drastically this whole business of crop improvement would be hampered without it.

Although systematic plant breeding is so recent a development—within the lifetime of some of us—is has already achieved a surprising number of triumphs. Among cereals the extension of spring wheat it perhaps the most remarkable. Even as recently as twenty years ago there was very little in Britain, and few sorts could really be recommended; but now, thanks to the Swedish plant breeders, some excellent varieties are available. Atle I have already mentioned; another is Atson, also a Weibull product, and a third is Fylgia, which comes from Svalov, and in England in the West Country has proved even better than Atle because it ripens earlier. The Finns also have done great things with spring wheat and have evolved strains requiring less and less time between sowing and harvesting so that they can be grown farther and farther to the north: in 1922 the northern limit of wheat cultivation in Finland was about lat. 63° N.; by 1946 it had been pushed up a line stretching from beyond lat. 66° in the west to lat. 64° in the east—a really remarkable extension. The War stopped further developments; but they are being resumed. The greatest triumphs with spring wheat are, of course, in Canada, where plant breeders have been so successful that the Prairie Provinces, which as late as 1860 were deemed little suited to farming and were sold by the Hudsons Bay Company to the Canadian Government for £300,000, are now the second largest wheat producing region in the world.

There still remain problems for the plant breeder. We have got to face the fact that plant diseases and pests are likely to increase. Of course, we hope they will not, but we are steadily making conditions more favourable for them by improving transport and upsetting Nature's equilibrium in many ways. For many of these diseases and pests the chemist has devised potent destroyers; but not by any means for all—the virus diseases cannot yet be cured though their carriers may be killed. By far the best way of avoiding disease is to grow resistant varieties. Fortunately, resistant varieties are at times found wild; but by one of Nature's little ironies resistance is often tied up with commercial uselessness, and it is for the plant breeder to untie the knot and carry the genes of resistance into commercially desirable varieties.

The supply of home-grown protein ought to be increased. The bean crop is not yet all we could like. Can anything be done about aphis and chocolate spot? Or to ensure heavier podding? It is not easy to understand why so little lucerne is grown. Various lines of work are proceeding at the National Institute of Agricultural Botany which bear directly or indirectly on these problems. Even worse is the shortage of oil-producing crops in Britain. Large quantities of vegetable oil are consumed; but very little is produced. Yet we shall need it in increasing quantities, for it is made into margarine, which is likely more and more to replace butter. Prof. G. E. Blackman at Oxford and the Institute have shown that existing varieties of the edible oil crops are not generally suitable in Britain (I am not referring to linseed). Before the War, Prof. Southworth, of Manitoba, who had been very successful there in improving the soya bean, tried a number of apparently promising sorts at Rothamsted without

result. So far, only one oil-producing family seems to grow well in these latitudes: the rape family. The Germans, the Swedes and the Finns have had considerable success with it: varieties have been produced in Sweden giving as much as 600 lb. of oil per acre (the average yield of oil is, of course, much less: in 1951 it was 320 lb. per acre), which would give roughly 600 lb. of margarine: in practice a mixture of oils is used, but rape oil gives roughly its own weight of margarine. Remembering that on well-managed farms in Britain, Holland and New Zealand the yield of butter fat is only 100–150 lb. per acre, and even by intensive close folding and high manuring it goes only to about 200 lb., one can see why margarine is so much cheaper than butter. Unfortunately, about half of the rape oil consists of the 22-carbon atom erucic acid type, while most of the other vegetable oils—palm kernel, coconut, groundnut, sunflower or soya—used for making margarine are of the 18-carbon atom oleic and linoleic acid types, which are perhaps better metabolized by the human body. Would it be possible to change the genetical composition of the rape by irradiation or otherwise so that the 18-carbon atom fats are built up instead of the 22? One scarcely dares to hope this: if it could be done, it would revolutionize our fat problem.

Turning from Britain to lands for the development of which we have responsibility, one of the greatest problems of the African territories is the maintenance of the soil fertility. In Britain we can do it by growing leguminous crops, especially the clovers. In the genial climate of the southern part of Australia subterranean clover has been marvellously successful—so long as the rainfall exceeds some 15–18 in. a year. But over large parts of East and Central Africa the rainfall is too low or, what comes to the same thing, the dry season is too prolonged to allow the growth of clover. It would be a great advance if some leguminous crop could be found or bred that would do for the African farmer what clover has done in Britain and in Australia. The wet regions of Africa call even more urgently for some new soil-ameliorating crops.

The National Institute of Agricultural Botany does not itself deal with these problems; but it does deal with the resulting products, and as cytology and genetics advance, new techniques of plant breeding will certainly be evolved. Already the Swedes have used artificially induced tetraploidy for getting a new variety of rye, and an X-ray technique for a new variety of winter mustard; but this is only a foreshadowing of what may come. (An important monograph on artificially induced mutations has just been published by the Royal Swedish Academy of Agriculture as a memorial to the great Nilsson-Ehle.) When the plant breeder has done all he can in finding and transferring desirable characters, some artificially induced mutation may enable him to make still further advances. In Britain also mutants are being sought: a cobalt unit has been set up at Aberystwyth for this purpose. We may be sure that the numbers of new varieties and strains will continually increase and their range will widen, making more and more demands on the staff of the Institute. We can be equally sure that the Director and staff will cope satisfactorily with these new problems, and in congratulating them on the impressive results of this year's work, we sincerely wish them equal success in the years that are to come.

THE LIPIDS IN FLOUR

OXIDATIVE CHANGES INDUCED BY STORAGE AND IMPROVER TREATMENT

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THE fat content of wheaten flour depends on the rate of extraction, increasing from about 0·8 per cent at 40 per cent extraction to about 2·5 per cent in a wholemeal[1]. Flour is thus a relatively poor source of lipids; but they, together with lipid-soluble constituents, are important in problems both of practical and fundamental interest. Thus, for example, while oxidative deterioration of lipids is the factor limiting the prolonged storage of flour[2] yet, on the other hand, some degree of oxidation appears to be associated with the improvement in baking quality which occurs when flour is stored in air or when it is treated with certain chemical improvers. There is also an increase in the degree of oxidation of the lipids during the mixing of dough in breadmaking, and the extent of this oxidation influences the quality of the bread made from untreated flour. Another practical point is that the colour of flour is in part determined by the extent of the oxidation of some of the fat-soluble pigments. Among the questions of more fundamental interest are those concerned with nutritional aspects, including the stability of the fat-soluble, biologically active forms of the tocopherols and the degree of oxidation of the unsaturated fatty acids[3].

Some of the effects produced by the action of the flour improver, chlorine dioxide, on the lipid fraction of flour have already been examined, mainly in a qualitative manner, and reported in a previous communication[4]. It was then noted that, under certain conditions, oxidation led to the formation of polymer-like material, presumably via an initial formation of hydroperoxides[5], and that there was a reduction in tocopherol content. These changes have now been studied in greater detail.

Oxidation of Lipids in Flour subjected to Different Treatments

In the earlier article a qualitative picture of the degree of oxidation or peroxide value was obtained by adapting the thiobarbituric acid method of Wilbur

et al.[6] to whole flour suspensions. This method, which has also been used on milk[7,8], is particularly useful in the present connexion both because of its sensitivity and its specificity. Furthermore, applied as below, it gives clear solutions suitable for measurement in a photoelectric colorimeter. The measurements have usually been made with petroleum ether extracts of the flour.

Method. The principle of the method involves: (1) reaction of the lipids with the thiobarbituric acid reagent and (2) separation of a clear solution of the pink complex (formed by the reagent with oxidized unsaturated fatty acid) from the reaction mixture. The conditions chosen for step (2) depend on the total amount of lipids present, since this influences the partition of the coloured complex between immiscible phases.

Details of the procedure, using samples containing about 50 mgm. total solids, are as follows:

Stage 1. *Reaction with the thiobarbituric reagent.* To an appropriate volume of extract, in a boiling tube, were added 1 ml. of a 5 per cent solution of trichloroacetic acid, 0·25 ml. of the commercial detergent 'Teepol' and 1 ml. distilled water. The solvent was evaporated off and 2 ml. of the thiobarbituric acid reagent of Kohn and Liversedge[9] added. The tube was heated in boiling water for 10 min. After cooling, 0·25 ml. of 'Teepol' was added and the contents transferred to a separating funnel.

Stage 2. *Extraction of the coloured complex.* The tube was washed out into the separating funnel with 1 ml. distilled water followed by 7 ml. of ethyl ether – ethanol mixture (2 : 1 v/v). The mixture was shaken vigorously, the phases allowed to separate, and the bottom phase, containing the coloured thiobarbituric acid complex, run into a 10-ml. volumetric flask. The phase remaining in the funnel was washed twice, each time with 1 ml. of aqueous ethanol (1 : 1 v/v). Each time the bottom phase was run into the flask. The contents of the flask were made up to the mark with an ethyl ether – ethanol mixture (1 : 2 v/v). Measurement of the colour of the solution from the graduated flask was made with an Eel colorimeter, filter 624, using as blank a volume of the solvent which had been subjected to the same procedure, namely, addition of reagents, boiling and phase separation. Aliquot volumes were chosen so that readings on the Eel scale were less than 40.

Table 1 gives the thiobarbituric acid values determined in this way for the lipids extracted from an untreated 80 per cent extraction flour, one week old, and for the lipids extracted from the same flour after treatment in the laboratory with the average commercial dose of nitrogen trichloride (NCl_3, or agene) and chlorine dioxide (ClO_2), namely, 60 and 30 p.p.m., respectively, applied to the whole flour. The lipids were extracted three days after treatment of the flour and the thiobarbituric acid values determined immediately.

Table 1

Flour	Untreated	Treated with nitrogen trichloride	Treated with chlorine dioxide
Thiobarbituric acid value (per 5 gm. flour)	2·1	9·7	7·0

Treatment of the flour results in an immediate small rise in the peroxide value. Differentiation between the treated and untreated flours becomes more marked, however, if the petroleum ether extracts are held at room temperature in the light.

Changes in petroleum ether extracts with time. (*a*) *Effect of different flour treatments.* The flours (untreated or treated with nitrogen trichloride or chlorine dioxide at commercial levels) were extracted at room temperature by percolating petroleum ether (40°–60°) through a column of flour (50 gm.) contained in a glass tube 2·5 cm. diameter and 45 cm. long. In each case 100 ml. extract was collected. The extracts were kept in stoppered flasks at room temperature in the light. Under these conditions, the thiobarbituric acid value increased, and eventually insoluble polymer-like material was deposited. The colour of the extracts was also measured, in the Eel photoelectric colorimeter using filter 622. Table 2 shows that these developments occur at different rates depending on the pretreatment of the flour.

In nine days the peroxide value of the extract of fresh untreated flour increased only slightly; there was a slow increase in the extract of five-week old untreated flour, a more rapid one with an eight-month old untreated flour. The value increased most rapidly in the extracts from flours treated with nitrogen trichloride and chlorine dioxide. Polymer-like material was eventually deposited in all the extracts. The time at which it occurs is related to the increase in the peroxide value. Under the conditions we have employed, deposition appears to occur when the thiobarbituric acid value reaches about 160–280 per 5 gm. flour. This means that an extract from a treated flour usually deposits material much sooner than one from an untreated flour. As the polymer-like material is deposited, the thiobarbituric acid value of the supernatant liquid falls. The effect of treatment upon the colour of the extracts is apparent in the initial readings, and relatively little further differentiation in this respect occurred within the nine days.

(*b*) *Effect of solvent used for extraction.* With each solvent, 200 gm. of an 80 per cent extraction untreated flour, two weeks old, were extracted, by irrigation through columns at room temperature. 250 ml. of each extract were collected. 100-ml.

Table 2

Time (days)	Flour *A*, untreated, freshly milled		Flour *A*, treated NCl_3, 60 p.p.m.		Flour *A*, treated ClO_2, 30 p.p.m.		Flour *B*, untreated, 8 months old		Flour *B*, treated NCl_3, in mill, 8 months old		Flour *C*, untreated, 5 weeks old	
	T.B.A.* value	Colour†	T.B.A. value	Colour	T.B.A. value	Colour	T.B.A. value	Colour	T.B.A. value	Colour	T.B.A. value	Colour
0	2·1	10·5	9·7	2·6	7·0	2·9	2·4	10·5	3·0	4·0	1·6	10·2
3	2·4	10·4	11·3	1·8	6·3	2·6	4·8	10·6	7·7	4·0	1·7	10·0
6	2·8	10·0	18·5	1·3	8·3	2·6	6·0	10·5	9·8	4·0	3·2	10·0
9	2·8	10·0	30·6	0·7	16·6	2·6	11·1	10·6	14·8	3·9	4·1	9·9

* Thiobarbituric acid value expressed per 5 gm. flour. † Colour of petroleum ether extract (100 ml. extract from 50 gm. flour).

Table 3

Time (days)	Held in the light: Carbon tetrachloride Colour	Carbon tetrachloride T.B.A.* value	Chloroform Colour	Chloroform T.B.A. value	Benzene Colour	Benzene T.B.A. value	Ethyl ether Colour	Ethyl ether T.B.A. value	Pet. ether b.p. 40°–60° Colour	Pet. ether b.p. 40°–60° T.B.A. value
0	22·0	0·5	28·5	0·4	25·6	1·3	20·7	0·7	16·8	1·0
1	1·0		10·4		24·1		20·0		16·8	
3	0·6	10·6	4·5	2·5	22·0	0·7	18·9	0·9	16·5	0·6
6	0·2	37·0	2·5	6·8	17·0	3·5	15·7	2·0	15·5	1·5
11	Polymer deposit	47·0	0·3	29·4	4·8	14·3	4·5	8·1	14·3	3·1
16	nil	54·5	nil	54·2	nil	21·3	nil	11·8	11·2	4·3
50										

Time (days)	Held in the dark: Carbon tetrachloride Colour	Carbon tetrachloride T.B.A. value	Chloroform Colour	Chloroform T.B.A. value	Benzene Colour	Benzene T.B.A. value	Ethyl ether Colour	Ethyl ether T.B.A. value	Pet. ether b.p. 40°–60° Colour	Pet. ether b.p. 40°–60° T.B.A. value
0	22·0	0·5	28·5	0·4	25·6	1·3	20·7	0·7	16·8	1·0
1	22·0		28·7		25·7		20·9		17·0	
3	21·9	0·9	28·7	0·7	25·3	1·0	21·0	0·6	16·6	0·8
6										
11										
16	21·0		27·2		23·9		20·3		16·5	
50	20·5	2·3	27·7	4·6	23·3	0·9	20·4	1·8	15·7	2·0

* Thiobarbituric acid values expressed per 0·8 gm. flour

Days in light for perceptible deposition of polymer-like material: carbon tetrachloride 10; chloroform, 19; benzene, 20; petroleum ether 27 ethyl ether, 30 (the longer time with ethyl ether is probably due to the material having a relatively higher solubility in this solvent. Thus, polymer-like material from petroleum ether is partially soluble in ethyl ether)

samples of each were held in the light and in the dark, and measurements of the colour and the thiobarbituric acid values were made initially and at intervals thereafter. The thiobarbituric acid values were determined on 1 ml. of extract, which is equivalent to 0·8 gm. of flour. For these extracts containing less than 10 mgm. total solids, a modified procedure was followed. In stage 1, 3 ml. distilled water and 1 ml. of the thiobarbituric reagent were used; addition of 'Teepol' after heating was omitted. In stage 2 the tube was washed out with 1 ml. distilled water followed by 5 ml. ethyl ether – ethanol mixture (2 : 1 v/v). The upper phase was washed only once with 1 ml. distilled water and the contents of the flask made up to the mark with ethyl ether – ethanol mixture of 1 : 2 (v/v). For this particular experiment a small sample was chosen because of the large increase in the thiobarbituric acid value which occurs in the extracts kept in the light. This results, however, in a larger experimental error with samples with a low thiobarbituric acid value. For these it is preferable to use, as in Table 2, a volume of extract equivalent to 5 gm. flour. The results obtained are given in Table 3.

In the dark all the extracts are comparatively stable. In the light, extracts in carbon tetrachloride and chloroform rapidly autoxidize and become bleached. This also occurs with the other solvents but less quickly, petroleum ether extracts showing the greatest stability.

Reducing Substances in the Unsaponifiable Fraction

The unsaponifiable fraction of flour lipids contains pigments, steroids and tocopherols. It is an important fraction, since it contains components which contribute to the antioxidant properties of the parent flour. These influence the colour and determine the vitamin E content; some of them are extremely sensitive to oxidation, and this is reflected in a diminution of the total reducing value of the unsaponifiable fraction[4].

The reducing value of the unsaponifiable fraction towards the system ferric chloride α-α′-dipyridyl is largely due to α- and β-tocopherols, to an unidentified substance first noted by Brown[10,11] on paper chromatograms, afterwards observed by Eggitt and Ward[12] and in the present work, to carotenoid pigments and possibly sterols. From our observations using chromatographic techniques, about 40 per cent of the total reducing value is due to α- and β-tocopherols and about 30 per cent is due to the unidentified substance. Details of this aspect of the work will be published elsewhere.

Saponification of the flour lipids and measurement of the total reducing value of the unsaponifiable fraction were carried out by the methods of Tosic and Moore[13]. The colorimetric estimations were made with an Eel photoelectric colorimeter (filter 624). A standard curve was prepared using synthetic α-tocopherol, and the figures for total reducing value are expressed in terms of the reducing value of α-tocopherol.

The sensitivity of the total reducing value as an index of the treatment of flour with an oxidizing agent is illustrated in Table 4, in which values for an untreated flour are compared with those for the same flour when treated with nitrogen trichloride in the laboratory at about the commercial level. (In commercial practice it is not the final flour which is treated; instead, the constituent mill-streams are given different levels of treatment. The figures of 60 and 30 p.p.m. for nitrogen trichloride and chlorine dioxide respectively are the mean values calculated on the weight of the final flour.) The table also includes values for two flours (80 per cent extraction) both of which had been stored under the same con-

Table 4

Flour	Treatment	Total reducing value of unsaponifiable fraction (μgm./100 gm. flour)
Same stock 2 weeks old	None	2,320
	NCl_3 15 p.p.m.	1 660
	„ 30 „	1,180
	„ 60 „	410
Same stock 8 months old	None	2,140
	Treated with NCl_3 at mill	470

ditions for eight months. One of these was untreated and the other was from the same batch of flour but which had been treated with nitrogen trichloride at the mill.

Lipids extracted from Different Types of Flour

Measurements of the kind described above have been made on lipids extracted from a range of flours, and are given in Table 5. These include flours freshly milled in the laboratory, of 30, 70, 85 and 100 per cent extraction, from a good-quality Manitoba wheat, and samples sent to us of recently imported commercial consignments of Canadian National flour.

Table 5

Flour	Total reducing value of unsaponifiable fraction (μgm. /100 gm. flour)	Colour of petroleum ether extract (100 ml. extract from 50 gm. flour)	Thiobarbituric acid value expressed per 5 gm. flour
Series 1. Untreated and chemically treated 80% extraction flour			
Untreated flour *A* 2 weeks old	2,320	10·5	2·1
Treated flour *A*			
ClO_2, 7·5 p.p.m.	1,030	9·3	—
„ 15 p.p.m.	465	6·2	—
„ 30 p.p.m.	120	2·6	7·0
NCl_3 15 p.p.m.	1.660	6·1	—
„ 30 p.p.m.	1,180	4·5	—
„ 60 p.p.m.	410	2·6	9·7
Untreated flour *B*, 8 months old	2,140	10·5	2·4
Same flour *B*, but treated NCl_3 at mill	470	4·0	3·0
Series 2. Laboratory milled untreated flours of different extraction (Manitoba grist)			
30% extraction	1,600	9·7	—
70% extraction	1,930	10·0	—
85% extraction	3,020	12·2	—
100% extraction	3,420	8·2	—
Bran	5,700	7·3	—
Commercial germ	33,700	84·0	—
Series 3. Imported Canadian National flours (history unknown)			
Sample 1	2,360	10·1	2·0
„ 2	1,255	5·0	—
„ 3	1,270	5·2	—
„ 4	1,410	5·9	—
„ 5	750	3·4	19·0
„ 6	1,220	4·6	2·0
„ 7	1,200	4·7	6·6
„ 8	750	3·7	13·3
„ 9	330	1·8	8·0
„ 10	1,820	8·3	2·0

These data show that the total reducing value is the most sensitive index of the effect of the gaseous flour improvers. These agents have an immediate marked effect on this value, which is much less affected by storage of the flour. Similarly, the colour of the extracted pigment is more sensitive to the action of the improvers than it is to normal atmospheric oxidation. It should be noted that this may not hold when the flour is wetted, made into a dough and agitated in air or oxygen. These conditions are then more favourable for the action of oxidizing enzyme systems which may be coupled with the bleaching of the pigments. Although flour stored in air for several months shows only a relatively small reduction in the figure for total reducing value and the colour of the extracted pigment, there is a steady rise in the peroxide value of the extracted lipids, as measured by the thiobarbituric acid test.

These observations suggest that one of the immediate results of the application of the gaseous improvers is a reduction in the effectiveness of the antioxidants present in the flour, notably the tocopherols. This is consistent with the comparatively rapid rise in the peroxide value when extracts from flours so treated are held at room temperature in the light. By contrast, the antioxidants are less susceptible to atmospheric oxidation; but the lipids, possibly the phospholipid fraction, undergo a slow oxidation which is reflected in the peroxide value.

The results with the flours of different extraction are of interest in relation to the anatomical parts of the wheat grain. The figure for total reduction value rises with the extraction, while the colour due to pigment extracted with petroleum ether rises up to 85 per cent extraction, but is less with a wholemeal than a 70 per cent extraction flour. This behaviour is due to the high figure for the total reducing substances in the germ and bran, the high value of the figure for the extracted pigment from germ and the relatively low value for bran. The 30 and 70 per cent flours are mainly endosperm material, while much of the germ and some bran is contained in the 85 per cent extraction flour.

One practical application of these observations is that they indicate the basis of a method of deciding whether or not a flour has been treated with one of the gaseous improvers (nitrogen trichloride or chlorine dioxide). (The bleaching agent, benzoyl peroxide, would probably react in similar fashion; but as it leaves an equivalent residue of benzoic acid its use could readily be checked.) Thus, in the Canadian samples examined it would be inferred, for example, that sample 1 and probably 10 were wholly untreated, whereas sample 9 and probably samples 5 and 8 had been given our normal commercial improver treatment for 80 per cent flour. It would also appear that the remaining five samples had received some degree of treatment. This aspect of the work, however, requires a comprehensive survey with a wide range of samples of flour of known history (grist, extraction-rate, age, etc.) in order to standardize it.

[1] McCance, R. A., Widdowson, E. M., Moran, T., Pringle, W. J. S., and Macrae, T. F., *Biochem. J.*, **39**, 213 (1945).
[2] Greer, E. N., Jones, C. R., and Moran, T., *Cereal Chem.* (In the press).
[3] Holman, R. T., and Greenberg, S. I., *Arch. Biochem. and Biophys.*, **49**, 49 (1954).
[4] Moran, T., Pace, J., and McDermott, E. E., *Nature*, **171**, 103 (1953).
[5] Lea, C. H., *Chem. and Indust.* Dec. 5, p. 1303 (1953).
[6] Wilbur, K. M., Bernheim, F., and Shapiro, O. W., *Arch. Biochem.*, **24**, 305 (1949).
[7] Patton, S., and Kurtz, G. W., *J. Dairy Sci.*, **34**, 669 (1951).
[8] Dunkley, W. L., and Jennings, W. G., *J. Dairy Sci.*, **34**, 1064 (1951).
[9] Kohn, H. I., and Liversedge, M., *J. Pharmacol.*, **82**, 292 (1944).
[10] Brown, F., *Biochem. J.*, **52**, 523 (1952).
[11] Brown, F., *J. Sci. Food Agric.*, **4**, 161 (1953).
[12] Eggitt, P. W. R., and Ward, L. D., *J. Sci. Food Agric.*, **4**, 176 (1953).
[13] Tosic, J., and Moore, T., *Biochem. J.*, **39**, 498 (1945).

RADIOISOTOPE CONFERENCE AT OXFORD

THE Second Radioisotope Conference organized by the Atomic Energy Research Establishment, Harwell, was held at Oxford during July 19–23, with the object of discussing the experimental uses of radioisotopes and new techniques in their various applications in medicine, biology, agriculture, chemistry, physics, engineering and industry. The organizers of the Conference took the bold step of accepting only seventy-one out of more than two hundred papers which were proffered; this removed the usual scourge of conferences—an overcrowded programme and multiple sessions in parallel. Another notable achievement was the issue of preprints of all the papers well in advance of the Conference, and the limitation of the time of reading each paper to ten minutes; this allowed a considerable amount of time for discussion, which was very lively and stimulating.

The Conference started off with several papers dealing with the therapeutic applications of radioactive isotopes. Some of these are used as external applicators much in the same way as radium, but utilizing the special advantages offered by the new radioactive substances. R. C. Tudway, H. F. Freundlich and T. S. M. Marshall (Bristol) used iridium-192 as a cervix applicator; the soft γ-rays from iridium make shielding of neighbouring organs much easier. Similarly, yttrium-90, which was used by F. Crainz (Catania), lends itself to intra-uterine application, as it is a pure β-ray emitter. F. Ellis and R. Oliver (Oxford) demonstrated the use of tantalum wire containing tantalum-182 as an applicator; the great flexibility of these wires makes them less likely to obstruct blood vessels than the rigid radium needles.

The internal use of radioisotopes in therapy depends on the ability to concentrate the radioactivity in the organ to be irradiated. One such method, which may be used for the treatment of cancer of the lung, was developed by E. E. Pochin, G. B. Cook, R. M. Cunningham, A. Hollman, F. Hudswell and B. R. Payne (University College Hospital, London, and A.E.R.E., Harwell). Colloidal gold, containing gold-198, is precipitated on sugar charcoal particles which are too large (30–43 μ in diameter) to pass through the lung capillaries. If injected intravenously they will therefore be concentrated in the lungs, with only a very small fraction reaching the liver. This preparation can also be localized in any specified area of the lung by means of cardiac catherization. J. Van der Werff (Nijmegen) described a somewhat similar use of bismuth-206 for deposition in the reticulo-endothelial system.

In the field of diagnosis, radioiodine is still the chief isotope employed in a variety of new problems. Very interesting results were obtained by H. G. Thode, C. H. Jaimet and S. Kirkwood (Hamilton, Ontario) on the uptake of iodine-131 by the salivary glands. It appears that a simple procedure, the comparison of the activity in a sample of saliva with that in the blood, provides a very sensitive method of discriminating between various types of thyroid disorders; the mechanism of the uptake in the salivary glands is not quite clear. The possibility of diagnosing carcinoma of the thyroid by means of a simple iodine-131 test was described by J. Rotblat and G. Owen (St. Bartholomew's Hospital, London), and the technique of outlining the thyroid and the location of tumours was improved by H. C. Allen, jun., J. R. Risser and J. A. Greene (Houston, Texas), who employed for this purpose a crystal spectrometer with a double discriminator coupled to a scanning and recording device. A comparison of the behaviour in the body of iodine-131 and its analogue astatine-211 has been carried out by J. G. Hamilton, P. Wallace-Durbin and M. W. Parrott (Berkeley, California); astatine, being an α-emitter, offers many advantages over the β-emitting iodine isotopes, but Dr. Hamilton emphasized the dangers involved in handling this element. Most of the experiments were carried out on rats; but the few studies on humans indicated some promising applications. The use of serum albumin labelled with iodine-131 for the determination of cardiac output was described by N. Veall, J. D. Pearson, T. Hanley and A. E. Lowe (Guy's Hospital and Hammersmith, London), who used a scintillation counter placed over the region of the heart and connected to a ratemeter and chart recorder; the method has still to prove its value, but the advantages it offers as compared with older methods of cardiac output measurements merits further study.

Iron-59 has been used in several investigations carried out in the Royal Cancer Hospital, London. E. M. Ledlie and C. Baxter described some clinical applications of this isotope in hæmatological investigations, particularly in the study of erythropoiesis bone marrow diseases. L. F. Lamerton, E. B. Harriss and E. H. Belcher carried out animal experiments on erythropoiesis and the effects of X-ray irradiation; they obtained very interesting results on protection achieved by shielding of the spleen. S. Rowlands, T. Freeman and P. C. Fleming (St. Mary's Hospital, London) developed a technique for making blood volume determinations in animals by the simultaneous use of two isotopes, phosphorus-32 and chromium-51. The latter isotope was also used by J. S. Robertson, R. Milne and S. H. Cohn (San Francisco) for observing the distribution of blood platelets in rats.

A somewhat unique use of radioisotopes was presented in a paper by F. P. Bowden, J. B. P. Williamson and P. Laing (Cambridge) on the metallic transfer in screwing and bolting which they studied by the autoradiograph technique using radiochromium. The connexion of this work with medicine arises from the fact that in operations on fractured bones a certain amount of metallic transfer may occur, sufficient to form an electrolytic couple which has a harmful effect on the healing of tissue.

J. ROTBLAT

St. Bartholomew's Hospital.

One session was devoted to methods of labelling compounds with carbon-14, tritium and iodine-131, three of the nuclides most used in medical and biochemical studies. In addition, the method of preparation of tritium used at the Atomic Energy Research Establishment was outlined by W. J. Arrol,

J. Chadwick, J. Eakins, C. Evans and E. J. Wilson. R. F. Glascock (National Institute for Research in Dairying) reported on the use of tritiated compounds for studying the metabolism of dietary stearic acid by the lactating goat. Acetic anhydride labelled with tritium and carbon-14 had been employed by P. Avivi, Sylvia A. Simpson, J. F. Tait and J. K. Whitehead (Middlesex Hospital) to elucidate the structure of electrocortin and to estimate it and hydrocortisone in human peripheral blood. A paper from the National Institute for Medical Research described how high specific activity rabbit fibrinogen, albumin, normal and antibody globulins had been formed by biosynthesis using whole dried algae, labelled with carbon-14. The preparation of the algae had already been reported to the conference by J. Catch (Radiochemical Centre, Amersham). G. Wolf, B. Connor Johnson and S. G. Kahn (University of Illinois), who have synthesized vitamin A-2-^{14}C, gave preliminary experimental results on its metabolism after injection into rats. An invigorating discussion followed the note by E. Kallee (Tübingen) on the detection of as little as 0·001 μgm. of proteohormone insulin by paper electrophoresis after intravenous injection of rats with radioactive iodide, iodine-131 labelled serum and insulin. The use of cobalt-60 labelled vitamin B_{12} (C. Rosenblum, U.S.A.), the biosynthesis of penicillin (H. R. V. Arnstein) and the use of carbon-14 labelled sugars in the study of carbohydrate metabolism of the leaf (Helen K. Porter and L. H. May) were among some of the other contributions of interest to biochemists.

Among the papers dealing with plant nutrition and allied subjects, L. Ehrenberg, I. Granhall, A. Gustafsson and N. Nybom (Sweden) gave an interesting description of their first season's work on the irradiation of growing plants (barley, fruit trees, etc.) with a cobalt-60 gamma-ray source. The fruit trees showed a series of morphological aberrations such as clustering of leaves and shoots, formation of bifurcated shoots and irregular leaves. The topical subject of foliar fertilization has been studied by K. Kaindl (Austria) with phosphorus-32 labelled phosphatic nutrient. In the discussion, R. Scott Russell (Oxford) pointed out the large amount of fundamental work still to be done before the practical usefulness of foliar nutrition could be assessed. Another approach to the problem of making phosphorus available to plants was that of O. Talibudeen (Rothamsted), who had carried out experiments using phosphorus-32 to determine the readily exchangeable phosphates in soils.

Papers of interest to chemists included a description of the meticulous work by C. J. Collins and W. A. Bonner (Oak Ridge, Tennessee) on the use of carbon-14 to investigate the Wagner–Meerwein rearrangement in the study of 1 : 2 : 2-triphenylethanol and its derivatives. Various aspects of the labelling of ring labelled compounds were dealt with by H. S. Turner (Chemical Research Laboratory, Teddington). The experiments of A. G. Maddock and H. Behrens (Cambridge) on the exchange reaction between iodine and methyl iodide provoked much useful discussion. The kinetics of the process were outlined, and it was shown that there was a chain reaction initiated by radiation which involved the production of free radicals. The branching of vinyl polymers (J. C. Bevington and H. W. Melville, Birmingham), the use of carbon-14 to study the role of oxygenated radicals in the Fischer–Tropsch reaction (E. J. Gibson and A. W. Fletcher, Fuel Research Station, Greenwich), and the poisoning of solid catalysts used in the synthesis of ammonia (C. Bokhoven, Netherlands) illustrated further applications of the radioisotope technique.

A beautiful illustration of the usefulness of tracers combined with radioactivation analysis was given by P. Albert, F. Montariol, R. Reich and G. Chaudron (France) in their investigations of the purification of aluminium from zinc, copper, sodium and silicon by zone melting. Another interesting metallurgical paper was that by M. C. Inman, D. Johnson, W. L. Mercer and R. Shuttleworth (University of Leeds) describing their careful measurements on the self-diffusion coefficients of copper and zinc into alpha- and beta-brass.

In the first of two important practical applications of neutron sources, C. P. Haigh (Barrow Hospital, Bristol) described a measurement of the neutrons generated in the $^{24}Na(\gamma,n)^{23}H$ reaction as a method of assay for heavy hydrogen. In the discussion on the paper by A. H. Knight (Macaulay Institute for Soil Research, Aberdeen) on the measurement of soil moisture by neutron scattering, no satisfactory reason was found why organic matter in the soil did not have a greater practical effect on the measurements reported. Results obtained on archæological specimens with the new carbon-14 dating method developed by A. R. Crathorn and W. R. Loosemore (Royal Institution and Atomic Energy Research Establishment) were presented. The method involves the conversion of the specimen into acetylene which is used as the filling gas in a proportional counter. The supplementary method of B. N. Audric and J. V. P. Long (Chemical Research Laboratory, Teddington), utilizing the acetylene dissolved in a liquid phosphor at − 78° C., has not yet been used for dating specimens.

Of the two new thickness gauges of interest to industry, that developed by J. L. Putman, S. Jefferson and J. F. Cameron (Atomic Energy Research Establishment) was very ingenious. The method was developed for measuring from the outside of pipes the degree of corrosion on the inside of the pipe wall. The gamma-ray source is cobalt-60 and the scintillation counter detector has a gating circuit so that only radiation which has suffered a change of energy by scattering from the pipe wall is measured. One advantage of this system is that no heavy lead shielding is required. Other industrial applications included the use of phosphorus-32 labelled wool fibres to study the very difficult problem of drafting (D. S. Taylor, Leeds), a study of water flow and velocity measurements (A. Montens, Germany) and the wear of carbide-tipped cutting tools (L. G. Erwall, Sweden). Of the papers dealing with new nuclides for use in industrial gamma radiography, that utilizing thulium-170 (gamma energy 84 keV.) was of most immediate practical importance. In the final paper L. E. Brownell and J. V. Nehemias (University of Michigan) illustrated how a ten-thousand curie cobalt-60 gamma-ray source was used for sterilizing foodstuffs by irradiation, and mentioned briefly the very interesting possibilities of initiating chemical reactions by this means. A short closing address was given by Dr. Henry Seligman, head of the Isotope Division, Atomic Energy Research Establishment, who has been primarily responsible for initiating the two Radioisotope Conferences that have been held.

The papers presented at the Conference, together with the discussions, will be published in book form

in November 1954 by Butterworths. There will be two volumes: vol. 1 will cover medical and physiological applications, and vol. 2 physical sciences and industrial applications.

In addition to the formal papers, there were films illustrating radioisotope techniques used in hospitals and laboratories. By the courtesy of Lord Cherwell, the Clarendon Laboratory was available for a well-laid-out exhibition covering instruments, laboratory techniques and a representative range of manufacturers' equipment (representing five different countries) of interest to radioisotope users. This was a centre of activity throughout the week.

J. E. JOHNSTON

CHEMISTRY IN RELATION TO THE DEVELOPMENT OF THE NERVOUS SYSTEM

THE Mental Health Research Fund organized the First International Neurochemical Symposium at Magdalen College, Oxford, during July 13–17. The Symposium was planned as part of a series, and the field selected for the first meeting was "Chemistry in Relation to the Development of the Nervous System". The organizing committee consisted of J. Elkes (Birmingham), L. Flexner (Philadelphia), J. Folch-Pi (Boston), G. W. Harris (London), S. S. Kety (Washington), D. Richter (Cardiff) and H. Waelsch (New York).

The Symposium was attended by approximately seventy scientific workers, forty being from abroad—from Belgium, Canada, Denmark, Germany, Italy, Norway, Sweden, the United States and U.S.S.R. It was arranged in morning and afternoon sessions, and on two days there was also an evening session. Each session started with one or two reviews, followed by communications on recent research; there was always a lively and full discussion, and this was recorded. The transcription of the Symposium will be published in the near future by the Academic Press, New York.

The first morning session, under the chairmanship of Sir Geoffrey Vickers, was characterized by two features: the regrettable absence of Dr. R. Lorente de Nó (New York), and the view expressed by the two anatomists in discussing some aspects of the early development of the nervous system (Prof. J. D. Boyd, of Cambridge) and of the vascular patterns of the nervous system (Dr. Horne Craigie, of Toronto) that chemical inductors are required for explaining the morphological development of the nervous system. Prof. Boyd emphasized the importance of the tissue and the spaces underlying the ectoderm in the development of the dorsal plate and the differentiation of the neural tissue, illustrating his points with a wealth of material from sheep embryos. Dr. Horne Craigie showed the wide range of vascular patterns presented in the development of a variety of species, and posed the question of the extent to which the pattern is determined by underlying changes.

The afternoon session, with Dr. R. W. Gerard (Chicago) in the chair, opened with a review of experimental neuroembryology in the chick by Dr. V. Hamburger (St. Louis), and an account of the functional development of the nervous system in the dogfish by Dr. H. P. Whiting (Bristol). Dr. Hamburger took up the theme of the morning session and reported on the dramatic changes in the growth of spinal and sympathetic ganglia produced by the influence of transplanted limb buds and tumour tissue. Dr. Whiting presented experimental evidence for dividing the developmental steps into the classical divisions of myogenic, neurogenic and reflexogenic, and in general supported the Coghill thesis of segregation of reflexes. There followed a communication by Dr. J. L. Malcolm (London) on his investigations into the appearance of inhibition and facilitation in the developing spinal cord of kittens. He showed that, during the first two post-natal days, an impulse sent in through the dorsal lumbar roots leads only to a single spike in the corresponding ventral root, but that later, with the appearance of after-discharge in the ventral root, facilitation and inhibition can be demonstrated. The session ended with a communication from Dr. D. Hill (London), in which he emphasized the important practical aspects of cerebral maturation as marked by the milestones which can be demonstrated by the electroencephalogram rhythms.

The second day started, under the chairmanship of Dr. S. S. Kety, with a detailed review by Dr. Folch-Pi of the composition of the whole brain of mice during post-natal maturation, with particular reference to phospholipids, a review which was based to a great extent on the extensive work done in his own laboratory. This review was followed by Dr. H. Klüver's (Chicago) careful fluorospectrographic analysis of porphyrins in the central nervous system. They are not present in the central nervous system of reptiles, amphibians and fishes, and are found in warm-blooded animals only after birth—for example, in rats at the age of 20–25 days, a time which is associated with a number of functional advents. Porphyrins occur first in the ventral roots and last in the cerebrum; Dr. Klüver thinks their presence is related to the developing oligodendroglia. These photodynamic substances may be affected by the amount of light known to be transmitted through the skull in some species, and the interesting question arises as to the extent to which light may, by these means, affect nervous system activity and also, perhaps, the sexual cycle. Dr. P. Diezel (Heidelberg) presented histochemical evidence of the distribution of iron throughout the brain substance, and pointed out the considerable amounts which appear in the glial cells during development, while Dr. G. Brante (Eskilstuna) reported on the presence of polysaccharide substances in the nervous tissue of developing mice. Dr. A. F. W. Hughes (Cambridge) described his technique for the refined densitometry measurements of ribonucleic acid in the developing chick embryo, and was able to demonstrate its appearance and distribution in the ventral horn cells and its relationship to the Nissl substance. The morning session finished with an account by Dr.

D. R. Davies and Dr. L. C. Thomas (Salisbury) on their infra-red spectrophotographic method for measuring quantitatively the myelin in the developing nervous tissue. They stressed the point that this method might be applicable to a number of problems associated with myelination.

The afternoon session, under the chairmanship of Prof. H. A. Krebs, started with a carefully worked out review by Dr. D. Richter (Cardiff) on the chemistry, particularly enzymes and substances such as acetylcholine, glutamic acid and glycine, in the developing brain. The material, which was often given in clear tables, will be of great use for subsequent reference when published in the Symposium. Dr. S. S. Kety (Washington) reported on his work, with the nitrous oxide method, on the oxygen consumption of the brain in the human, and made the observation that at birth nearly 80 per cent of the oxygen consumption is accounted for by brain metabolism, that between ten and twenty years the percentage is more than 50, and that later it falls to about 25 per cent. Then Dr. H. McIlwain (London) gave an account of his experiments, together with Dr. P. Greengard, on the oxygen consumption of tissue slices of the cerebral cortex of rats and guinea pigs of varying ages. They showed how the oxygen consumption can be raised to an increasing extent with age by means of electrical potential gradients in the Warburg chamber, the presumption being that such potentials stimulate the cortical tissue to activity comparable to that found *in vivo*. The role of non-nervous tissue was assessed by comparable measurements on gliomas. Dr. R. W. Sperry (Pasadena) followed with an account of the effects of transplanted skin in tadpoles and its effect on subsequent innervation, and, most intriguing, the re-organization of the connexions in the central nervous system.

An evening session was held on the second day, and for this the chair was taken by Dr. L. B. Flexner (Philadelphia). The subject of the geometrical properties of the constituents of the nervous system was ably outlined by Dr. A. Pope (Boston), who discussed, among other problems, the quantitative aspects of inter- and intra-cellular material. The remainder of the evening was devoted to histochemistry of a most refined nature. Dr. O. H. Lowry (St. Louis) gave a fascinating account of his technique for weighing and the subsequent chemical analysis of individual neurones, a feat which won the universal admiration of the audience, as did his apparently casual method of presentation. No less interesting was Dr. H. Hydén's (Gothenburg) description of his methods of measuring the light and X-ray absorption of single nerve cells, from which the lipid protein and ribonucleic acid content can be assessed. How many of his audience envied him a machine which automatically types the results!

On the morning of the third day, with Sir Rudolph Peters in the chair, Dr. H. Waelsch (New York) opened by reviewing the differences in the rate of replacement of substances in the developing and adult brain; the results were obtained with the use of the isotope technique. He showed that in the first week of the developing brain of rats 40 per cent of the fatty acids is replaced, whereas there is a much smaller turnover in the adult rat. With the exception of glutamine, he has obtained no evidence that amino-acids are synthesized into the adult brain; however, from experiments on tissue cells there is some indication that essential amino-acids may be synthesized in immature brain tissue; but the mechanism of the uptake of these amino-acids is not clear. He stressed the point that in the embryonic or immature brain the blood–brain barrier appears to be absent; but so far the number of substances examined is not sufficiently large to allow this general conclusion. He was followed by Dr. H. E. Himwich (Galesburg), who gave an account of the relative rates of uptake of glutamine by adult and young rat brain, concluding that the rate of uptake in the younger age group is relatively greater. The lipid content of the brain was discussed by Dr. W. M. Sperry (New York) as well as by Dr. R. M. C. Dawson (Oxford). Dr. Sperry's results were obtained from human material from 4 to 40 days post natal, and he emphasized the need to correlate the increased lipid content over this period not only with the rate of medullation but also with the changes in the water and nervous tissue space. Dr. Dawson presented evidence of the rate of deposition of phospholipids in the young mouse brain, and presented evidence for a phospholipid metabolic cycle. Prof. A. V. Palladin (Kiev) read a paper on the metabolism of nucleic acids in the developing brain. Investigations in his Institute have shown that the protein content increases during the development of the brain, that despite the concomitant decrease in nucleic acid content the metabolism increases, that the grey matter of the cerebrum has a higher content of nucleic acids, of ribonuclease, and of desoxyribonuclease than the white matter, and that the cerebellum is rich in nucleic acids, especially desoxyribonucleic acid. He stressed the important role of these substances during the morphological and functional development of the brain. Prof. G. E. Vladimirov (Leningrad) in his report dealt with the role of the blood–brain barrier, and presented data collected during the turnover of such substances as adenosine triphosphoric acid, creatine phosphate, etc., using labelled phosphorus. By estimating the iron in blood, in brain tissue free from blood, and brain tissue containing blood, the quantity of blood contaminating the brain tissue was assessed, and errors in estimating the true intracellular content of phosphorus avoided. By such experiments the specific activity of intracellular inorganic phosphates is found to be equal to that of adenosine triphosphate.

The afternoon, with Dr. W. Feldberg (London) in the chair, saw the presentation of a great deal of evidence for the change in enzyme content in relationship to age. Dr. L. B. Flexner (Philadephia) opened with a survey of the growth of various enzyme systems in the guinea pig cortex, and he was able to relate their appearance with that of the cortical electroencephalogram, the presence of strychnine spikes, and the development of the earliest movements evoked by stimulation of the cortex. He presented evidence for a large increase in the chloride and sodium space at a time (forty-sixth day) when recognizable electroencephalogram patterns and strychnine spikes are observed. In the ensuing discussion some scepticism was expressed about the interpretation of the difference between sodium and chloride spaces in terms of Hodgkin's theory of a sodium pump mechanism as a basis for neuronal activity. Both Dr. H. E. Himwich (Galesburg) and Prof. J. Elkes and Dr. A. Todrick (Birmingham) presented figures for the rate of appearance of cholinesterases in the various parts of rat and rabbit brain, while Dr. M. A. Gerebtzoff (Liège) presented histochemical studies of the distribution of cholin-

esterases in the rat spinal cord. None of these findings could yet be directly tied to actual functional investigations. The session concluded with a paper by Dr. W. K. Jordan (Little Rock) on the increase of adenosine triphosphate in the rat cortex and cerebellum during the first forty days after birth. The increase was correlated with the appearance of spontaneous action potentials which began as short bursts of activity. In the cortex the periods between the bursts greatly decreased between the tenth and twentieth day; in the cerebellum at a somewhat later period.

Prof. L. S. Penrose took the chair on the morning of July 16, when Dr. Salome G. Waelsch (New York) outlined some of the genetic factors involved in the development of the central nervous system, in which she gave a stimulating account of her own work on mutations of mouse central nervous system. Of particular interest were her experiments in the modification of genes by antigen–antibody reactions, and her preliminary findings indicate an extremely interesting future for this method of investigation. The second review, by Prof. E. Klenk (Cologne), was on the possible role of cerebrosides in the pathology of the nervous system. Two short papers presenting original material by Dr. R. W. Gerard and Dr. L. Abood (Chicago) and by Sir Rudolph Peters (Oxford) completed the morning. Drs. Gerard and Abood have investigated the chemistry of the nervous system of the *Dba* strain of mice which between the twenty-eighth and thirty-sixth day post-natal is extremely susceptible to auditory stimulii. Dr. Gerard suggested that the low adenosine triphosphatase activity found at this period could account for the apparent hyper-excitability of the nervous system, if the membrane potential is related to the creatine phosphate content. Sir Rudolph Peters spoke about his interesting experiments on convulsions produced by fluorocitrate and its probable mode of action as a competitive inhibitor of aconitase; he discussed the probable reasons for the inability to reverse the competitor by calcium.

In the afternoon session, under the chairmanship of Prof. R. Gjessing (Oslo), the chemical changes accompanying well-defined mental defects were considered. Prof. L. S. Penrose (London) spoke about the genetic factors involved in the transmission of a number of known metabolic deficiencies, and Dr. H. Bicket (Birmingham) described the control of phenylketonuria by a suitable diet in several cases which he had studied in collaboration with Dr. Gerrard and Dr. Boscott. Finally, Dr. H. Weil-Malherbe (Runwell) presented data on the relationship of blood adrenaline to a large series of mental diseases.

The evening session was devoted to films. Dr. Hughes showed, by means of some extremely good time-lapse photography, the growth processes of chicken neurones, growing in suitable culture media; a fine sequence showing mitosis of a neurone was included in this film. Dr. Feldberg showed a film made by him and Dr. S. Sherwood of the method used for introducing drugs beyond the blood–brain barrier directly into the lateral ventricles of the cat. The action of a series of drugs producing changes of awareness such as stupor, catatonia and anæsthesia, as well as motor effects such as scratching, itching, paralysis and convulsions, were clearly shown with this film. He stressed the fact that from this region of the brain we can easily produce, by the action of small amounts of drugs, conditions which have much in common with mental diseases in man—for example, epilepsy and schizophrenia. Dr. H. Bickel's (Birmingham) short film of the three cases of phenylketonuria, which had been discussed earlier in the day, showed dramatically the recovery which is possible with a diet low in phenylalanine. His film emphasized the difficulties inherent in the control of such cases and the need of hospitalization. Finally, a sound film from Prof. D. Bovet's laboratory in Rome demonstrated skilfully the use of the electro-encephalogram in the investigation of drug effect on the central nervous system.

In the closing session on the morning of July 17, with Dr. H. Klüver in the chair, the high standard of the previous days and the intense interest which had been shown in the discussions at all previous sessions were maintained. Prof. G. W. Harris (London) gave a brief but extremely lucid account of the early endocrine–nervous system relationships, with particular reference to the growth of control by the hypothalamus on the pituitary, and indirectly on other endocrine organs. Dr. D. Nachmansohn (New York) gave a short account of his conception of the basic biochemistry associated with the conduction of the nerve impulse, indicating the points in the energy cycles involved at which drug action might be expected to take place. The remaining papers related, in varying degree, to clinical problems, emphasizing their important place beside the highly theoretical discussions which had taken place on the previous days. Dr. J. T. Eayrs (Birmingham) described the relationship of a nerve cell and its background substance in cases of hypothyroidism, with particular reference to the probable inability of dendrites to grow when the background substance is deficient. Dr. M. Reiss (Bristol) presented evidence of the relationship between steroid hormone deficiencies and the incidence of mental states, and Dr. S. P. Hicks (Boston) showed the selective action of a number of agents, such as X-rays, on different parts of the developing nervous system. He gave some interesting data on the selective action of drugs, such as acetylpyridine, on certain parts of the nervous system. Finally, Dr. J. Elkes (Birmingham) spoke of the work done in collaboration with Dr. Eayrs and Dr. Todrick on the effect of inhibition of cholinesterase in the central nervous system during the period of development, pointing out that 80 per cent inhibition of this enzyme has little interference with subsequent development and function.

The closing remarks, presented by Prof. R. Gjessing (Oslo), admirably expressed the opinion and the feelings of all those present. He expressed their gratitude to the organizers for bringing such a comprehensive group of workers together, and felt that, if the symposium had only emphasized the many gaps in our knowledge, that alone would have made it worth while. He expressed the admiration of the meeting for the extreme thoroughness of the organization, which attended not only to their serious discussions but provided a most enjoyable evening in Magdalen College Hall with entertainment from the Oxford Madrigal Society and others. In fact, much of the success of the meeting was no doubt due to the many opportunities for informal discussion in the delightful surroundings of Magdalen College.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

The Flavour of Porridge

Nowadays, porridge is often insipid and lacking in its traditional flavour and aroma. Possibly one reason for this is that, in England at least, sugar is usually added, and the sweetish taste, while it does not mask any true porridge flavour, is sufficient for most people. In Scotland, on the other hand, the majority add salt—precisely why, despite many inquiries, we have been unable to ascertain—so that the porridge flavour is more important. In any event there is a traditional flavour, often described as 'nutty', associated with Scotch porridge, and it is the view of many that if this flavour were more general the consumption of porridge would increase.

Any flavour in porridge meal or flakes is developed during the initial kilning process. This is not a standard operation. The whole oats are dried down from a moisture content in the range 14–20 per cent (but usually about 17 per cent) to a final moisture content of 4–8 per cent, after which they are shelled and ground into meal. The source of heat may be coke or anthracite, and in the past oat husk was often thrown on the fire presumably with the object of producing some volatile product which then gave the kilned oat its flavour. The conditions of heating are not, however, constant as from one kiln to another, or in one operation within a single kiln. Broadly speaking, if the kilning is carried out at low temperatures (not exceeding about 80° C.) the resulting meal or flakes have no distinctive taste, whereas if the temperature is sufficiently high the meal will have a caramel-like bitterness or even a burnt flavour.

As part of a programme of research for the Oatmeal Millers of England and Scotland, we are investigating the physics of kilning, and inevitably we have also considered the problem of flavour. The full results will be published elsewhere; but meanwhile it is of interest to record that we have consistently produced the desirable porridge flavour by careful control of the conditions of kilning. The furnace gases, despite traditional belief, play no part, and the same flavour is obtained when the air is heated in an electric furnace. The optimum conditions correspond to the gentle drying of the oats down to an intermediate moisture content of about 8 per cent followed by a short toasting for twenty minutes in a current of air at 150° C. These conditions are, of course, not absolutely rigid, and a slight increase in the temperature can be compensated by a corresponding decrease in the time of toasting. The use of high air temperatures at the surface of the partly dried grain to obtain a short but severe heat treatment at the final stage of kilning is the essential feature. On crushing the grain the pleasant aroma is immediately apparent. It soon evaporates from exposed meal; but the flavour is associated with less volatile material and accordingly more persistent.

The work of Baker, Parker and Fortmann[1] has indicated that the aroma and flavour of bread are due largely to numerous organic substances produced in the crust at temperatures around 150° C. The substances thus produced range from the more volatile aldehydes like furfural and pyruvic aldehyde to the melanoidins associated with the browning reactions occurring in the crust. Similar reactions will occur in the kilning of oats, since the outer portions of the grain reach about the same temperature and also undergo slight browning. However, there would appear to be other substances produced which are responsible for the unique flavour of oatmeal. Thus, in laboratory tests we have found that the optimum conditions of heating to produce flavour in oats also apply to groats, albeit there is less tolerance to over-treatment and a tendency for a slight rancid flavour to be produced due to the absence of the protective husk. On the other hand, we have failed to produce the same characteristic nutty oatmeal flavour in wheat when it is submitted to similar treatment.

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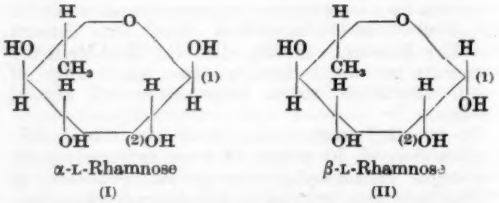
[1] Baker, J. C., Parker, H. K., and Fortmann, K. L., *Cereal Chem.*, **30**, 22 (1953).

Sweetness and Configuration in Rhamnose

The ordinary form of most reducing sugars, such as α-glucose, β-fructose and α-galactose, becomes gradually less sweet after dissolution, and in the meantime the sweetness reaches a constant value, since the ordinary form is converted in part into the less sweet isomer, and finally an equilibrium is attained between the two isomers: $\alpha \rightleftharpoons \beta$.

Several years ago, one of us[1] pointed out that the sweeter form of these reducing sugars always has *cis*-hydroxyl groups on the carbonyl and adjacent carbon atom, while in the less sweet isomer the hydroxyls on the two carbon atoms are *trans*; this was confirmed[1,2] by isolating and testing the α- and β-anomers with respect to sweetness.

From this rule it would be expected that in L-rhamnose the ordinary form (I) would be less sweet than the β-form (II), because the hydroxyls on C_1 and C_2 of the latter are *cis*. It has now been found that this is so.



α-L-Rhamnose (I) β-L-Rhamnose (II)

Three tasters compared the sweetness of a 4·29 per cent (calc. as anhydrous) solution of α-L-rhamnose ($[\alpha]_D^{23}$ − 13° → + 8·6°) with that of a 3·86 per cent solution of β-L-rhamnose ($[\alpha]_D^{23}$ + 41° → + 8·8°). Immediately after dissolution the β-rhamnose solution was, in spite of its lower concentration, much sweeter than the α-rhamnose solution; but with time the sweetness of the two solutions became closer, and after the lapse of fifteen minutes they were found equal in sweetness. After a further interval, the positions were reversed, the latter being distinctly sweeter than

the former. From this experiment it is possible to calculate the ratio of the degree of sweetness of the α- and β-form, as in the case of fructose[2].

The content of the α- and β-form in the two solutions at the moment of equal sweetness (15 min. after dissolution) was estimated by measurement of the mutarotation:

	$[\alpha]_D^{25}$	α-form	β-form
3·86 per cent β-rhamnose	+ 12°	54 per cent	46 per cent
4·29 per cent α-rhamnose	+ 6°	65 per cent	35 per cent

Representing the ratio of the sweetness of α- and β-rhamnose by x, it was found to be 0·39 from the relation, $(46+54x)/(35+65x) = 4{\cdot}29/3{\cdot}86$; that is, the sweetness of the α-form is less than two-fifths that of the β-form. This ratio is somewhat greater than that for fructose (0·33)[2], but much smaller than that for glucose (0·67)[1], showing that the difference of the sweetness of the α- and β-form of rhamnose is very remarkable. This fact is probably related to the comparatively rapid mutarotation.

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[1] Tsuzuki, Y., *Kagaku* (*Science*), **17**, 342 (1947) (in Japanese).
[2] Tsuzuki, Y., and Yamazaki, J., *Biochem. Z.*, **323**, 525 (1953).

Molybdenum in the Growth and Metabolism of *Chlorella*

Recent papers have shown the need of molybdenum for the growth of *Chlorella*[1] and *Scenedesmus*[2]. Some observations on the effect of molybdenum deficiency on the metabolism of *Chlorella* are recorded here.

Chlorella pyrenoidosa was cultured in purified nutrient solution in 250-ml. Erlenmeyer flasks with continuous shaking and illumination provided by fluorescent lights giving a light-intensity of 1,200 ft. candles at the base of the flasks. In Table 1 the effect of molybdenum on growth as measured by dry weight, chlorophyll content, photosynthesis and respiration of *Chlorella* cultures after five days growth is presented (means of four replicates).

Table 1. Effect of Molybdenum on Growth (Dry Weight), Chlorophyll, Photosynthesis and Respiration of *Chlorella*

Added Mo (μgm./l. culture)	Dry wt. (gm./l. culture)	Chlorophyll (% dry wt.)	Photosynthesis*	Respiration†
0	0·87±0·09	1·0±0·2	38±3	16 ±1
10	1·10±0·06	3·4±0·2	139±2	7·9±0·9

* Oxygen evolution expressed as ml. oxygen/gm. dry wt./hr., not corrected for respiration.
† Endogenous oxygen uptake expressed as ml. oxygen/gm. dry wt./hr.

Molybdenum-deficient cultures are characterized by their low chlorophyll content, and expressed on a unit dry-weight basis, low photosynthetic rate and high rate of endogenous respiration. The marked reduction of chlorophyll content of molybdenum-deficient cells has been reported by Arnon *et al.*[3] for *Scenedesmus*, and is perhaps one of the most characteristic features of molybdenum deficiency. The dry weight of molybdenum-deficient *Chlorella* cells was only slightly lower than that of the controls. In this respect, *Chlorella* at first sight behaved differently from *Scenedesmus*, in which molybdenum deficiency was associated with a sharp reduction in growth as measured by dry weight[3]. Recent results obtained by Arnon and Ichioka (unpublished), however, have shown that the dry weight, but not the chlorophyll content, of molybdenum-deficient *Scenedesmus* cells was markedly increased by the addition of vanadium, an element found to be essential for this alga[3]. In this respect the dry weight of the molybdenum-deficient *Chlorella* cells as shown in Table 1 is comparable to the dry weight found by Arnon and Ichioka for molybdenum-deficient *Scenedesmus* cells receiving vanadium.

The depression of photosynthesis in the absence of molybdenum is approximately proportional to the depression in chlorophyll content. Regardless of whether other factors were operative, the observed reduction of photosynthesis in molybdenum-deficient cells could be accounted for solely by their lower chlorophyll content.

Endogenous respiration was remarkably high in molybdenum-deficient *Chlorella*. In homogenized leaves of molybdenum-deficient tomatoes, Nason *et al.*[4] observed a marked lowering of endogenous respiration, a condition which might have been due to preparatory treatment. Spencer (unpublished results) has found increased respiration in molybdenum-deficient tomato leaves.

One of us (J. F. L.) gratefully acknowledges financial assistance from a Hackett studentship and a studentship from the Commonwealth of Australia Scientific and Industrial Research Organization. We wish to thank Dr. Victoria H. Lynch of the Radiation Laboratory for a culture of *Chlorella pyrenoidosa*.

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[1] Walker, J. B., *Arch. Biochem. and Biophys.*, **46**, 1 (1953).
[2] Arnon, D. I., Fujiwara, A., Wessel, G., and Woolley, J. T., American Soc. Plant Physiologists Program, Madison, Wis. (1953).
[3] Arnon, D. I., and Wessel, Gunilla, *Nature*, **172**, 1039 (1953).
[4] Nason, A., Oldewurtel, H. A., and Propst, L. M., *Arch. Biochem. and Biophys.*, **38**, 1 (1952).

Incorporation of Acetate-2-^{14}C into Human Erythrocyte Stroma as a Function of Storage

In an effort to elucidate the changes which may occur in the dynamic state of stroma constituents during storage of human erythrocytes (reported in part at the "Symposium on the Structural and Cellular Dynamics of the Red Blood Cell", June 1953: National Research Council, Washington, D.C.), we have studied the incorporation of acetate-2-^{14}C into red cell stroma under *in vitro* conditions using a technique previously described[1]. Venous blood from healthy donors was drawn under sterile conditions into cold *ACD* solution (each 100 c.c. of the *ACD* solution contained 2·45 gm. glucose, 1·37 gm. sodium citrate and 0·50 gm. of citric acid; 0·24 c.c. of *ACD* solution was added to each c.c. of blood) and then distributed as aliquots into an appropriate number of sterile tubes. These tubes were carefully sealed to prevent evaporation and were stored in two groups, one group at 4° C. and the other group at 37° C. At the intervals indicated in Fig. 1, tubes

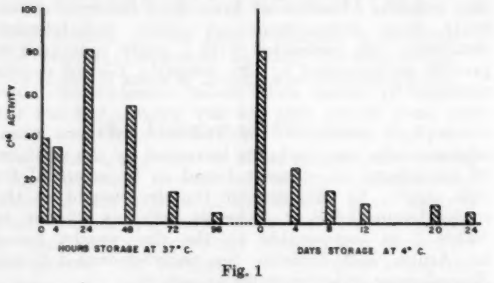

Fig. 1

were removed from the storage conditions and the incorporation of acetate-2-^{14}C into the total stromal fraction of the stored cells was determined. The composition of the incubation mixture for measurement of acetate incorporation was: 12·0 ml. of *ACD*-preserved whole blood, 1·5 ml. isotonic phosphate buffer at *p*H 7·4, 0·6 ml. of 0·3 *M* glucose in 0·9 per cent sodium chloride, and 1·5 ml. of sodium acetate-^{14}C (approximately 80 mgm.) in 0·9 per cent sodium chloride. The total amount of radioactivity added as labelled acetate varied from 4·9 to 6·3 × 10^6 disintegrations per minute per 12 ml. of whole, preserved blood.

The results of these experiments are shown in Fig. 1. They indicate that upon storage at either temperature there is a progressive loss in the ability of the erythrocyte stroma to incorporate acetate-2-^{14}C. After storage at 4° C. for four days, acetate incorporation decreases to 70 per cent of the initial value. There is a significant rise in incorporation of acetate after storage for 24 hr. at 37° C., followed by a rapid, progressive decrease in incorporation to about 70 per cent of the initial level after 72 hr. of storage at this temperature. After 96 hr. of storage at 37° C., the acetate incorporation exhibits a degree of depression comparable to that seen after twenty-four days of storage at 4° C. A rise in acetate incorporation comparable to that seen after 24 hr. of storage at 37° C. may well have occurred in the experiment where the red cells were stored at 4° C., but may have been undetected, because the first determination was carried out four days after storage was initiated.

These studies indicate that the ability of human red cells to incorporate acetate-2-^{14}C into the stromal fraction is diminished under storage. The diminution of the ability to incorporate acetate is dependent upon the temperature of storage, and may reflect alterations in the dynamic state of the stroma lipids under these storage conditions. Similar conclusions have been reached with respect to lipids and lipoproteins by Lovelock[2] in his studies on thermal shock in red cells. The technique employed here demonstrates an abnormality of erythrocyte stroma metabolism which occurs during storage at 4° C. at a much earlier time than the appearance of significant changes in post-transfusion viability of the red cells.

Upon storage of red cells in *ACD* at 37° C., the time required for these changes in acetate incorporation to occur is much shorter. This suggests that certain *in vitro* studies of red cell metabolic capacity designed to elucidate the abnormalities of red cell metabolism occurring upon storage at lower temperatures might appropriately be carried out at 37° C. The use of these high temperatures of storage might facilitate future studies of some of the abnormalities of red cell metabolism by similarly shortening the time-scale of such experiments.

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[1] Altman, K. I., *Arch. Biochem. Biophys.*, **42**, 473 (1953).
[2] Lovelock, J. E. *Nature*, **173**, 659 (1954).

A Position Effect of the *Rh* Blood-Group Genes

The opportunity has arisen of comparing the *C* and *E* antigens in the red cells of donors whose genotypes contain the same *Rh* genes, *D*, *C*, *E*, etc., but in different alignments.

Two comparisons have been made: that between red cell samples 1 and 2 in the table, and that between samples 3 and 4. All four samples gave reactions of about equal strength with some anti-*C* and some anti-*E* sera (columns *y* and *z*); but with other sera wide differences were revealed (columns *u*, *v*, *w* and *x*).

Scores representing the Strength of Reaction of Four Samples of Blood against Titrations of Six Selected Antisera

Genotype of donor	Antisera anti-*C* (*u*)	anti-*C* (*v*)	anti-*E* (*w*)	anti-*E* (*x*)	anti-*C* (*y*)	anti-*E* (*z*)
1. *dCE/dce*	0	2	73	87	93	34
2. *dCe/dcE*	39	55	6	13	93	24
3. *DCE/Dce*	0	0	75	71	75	33
4. *DCe/DcE*	34	43	29	31	91	33

All four genotypes have been confirmed by family groupings.
Genotype 1 has a frequency in Caucasians of perhaps 1 in 20,000.
" 2 " " " " " about 1 " 10,000.
" 3 " " " " " " 1 " 10,000.
" 4 " " " " " " 1 " 10.

The samples were taken on the same day within a few hours and in the same manner. Other examples of genotypes 1, 2 and 4 have been tested with similar results; we know of no other example of genotype 3. Control *dCe/dce* and *dcE/dce* samples showed that the gene *f* is not playing any detectable part in the *CE* effect.

The words *cis* and *trans*, introduced into genetics by Haldane, are useful here: in terms of *C* and *E*, samples 1 and 3 represent the *cis* arrangement and samples 2 and 4 the *trans*.

The influences of the *Rh* genes on each other are certainly very complicated; nevertheless, by confining ourselves to these two straightforward comparisons it is clear, from rows 1 and 3, that when *C* and *E* are in the *cis* arrangement *C* is inhibited and, from rows 2 and 4, that when *C* and *E* are in the *trans* arrangement *E* is inhibited. (The depression of *E* in genotype 4 though definite is not so extreme as that in genotype 2.)

A difference in phenotype between heterozygotes in *cis* and *trans* is precisely the sort of effect which, in other species, is such a striking characteristic of closely linked genes—genes between which crossing-over is rarely but regularly observed. Two examples may be quoted, namely, the lozenge genes of *Drosophila melanogaster*[1] and the biotin requirement genes

of *Aspergillus nidulans*[2,3]. In these examples two genes may appear to behave as allelomorphs in *trans* but not in *cis*, a phenomenon which has been called by Lewis[4] "position pseudo-allelism". However, the reactions of most anti-*C* and anti-*E* sera (exemplified by *y* and *z* in the table), together with the reactions of anti-*c* and anti-*e*, have never allowed *C* and *E* to be mistaken for allelomorphs.

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[1] Green, M. M., and Green, K. C., *Proc. U.S. Nat. Acad. Sci.*, **35**, 586 (1949).
[2] Roper, J. A., *Nature*, **166**, 956 (1950) and personal communication.
[3] Pontecorvo, G., *Advanc. Enzymol.*, **13**, 121 (1952).
[4] Lewis, E. B., *Advanc. Genet.*, **3**, 73 (1950).

A New Solvent for Silk

It has been shown recently by Schurz[1] that solutions of silk in phosphoric acid undergo a considerable decrease in viscosity on standing, which is probably due to degradation of the silk. Silk is insoluble in formic acid, although the latter is an excellent solvent for many polypeptides and nylon. On the other hand, concentrated aqueous solutions of many inorganic salts, for example, halides[2] and thiocyanates[3] readily dissolve silk, in some cases without degradation of the fibroin[4,5].

We have found that silk is very readily soluble in formic acid containing small quantities of water and certain inorganic salts at room temperature. Up to 20 per cent (w/v) of silk may be dissolved in these solutions, which are then semi-solid. Salts which are effective for rendering silk soluble in formic acid include lithium chloride, bromide, iodide and thiocyanate, magnesium, calcium, strontium, zinc and manganese chlorides, and calcium and barium bromides, whereas the alkali metal halides are almost ineffective. The salt concentration is related to the water content of the formic acid. Thus, using 90 per cent (w/w) acid 10 per cent (w/v) anhydrous calcium chloride is necessary, whereas with 98 per cent formic acid, only 2 per cent calcium chloride is required.

It is seen from the table of viscosity measurements that formic acid solutions of silk undergo far less degradation on standing than do solutions in phosphoric acid. The raw silk (from Lullingstone Castle Silk Farm, Kent) was first freed from sericin by treatment with a warm dilute solution of soap and ammonia, followed by washing with distilled water and drying at 110° C. Viscosities were determined in an Ostwald viscometer at 25° C., after filtering the solution through glass wool. Intrinsic viscosities $[\eta]$ were obtained by plotting reduced viscosities, η_{sp}/c (c is silk concentration in gm./100 ml. solution), against silk concentration for four values of the latter, over the range 0·2–1·0 per cent, and extrapolating the resulting straight lines to $c = 0$.

Time (hr.)	80% w/w H_3PO_4–H_2O $[\eta]$	80% w/w H_3PO_4–H_2O % decrease	90% w/w H_3PO_4–H_2O $[\eta]$	90% w/w H_3PO_4–H_2O % decrease	90% w/w H.COOH–H_2O + 10% (w/v) $CaCl_2$ $[\eta]$	90% w/w H.COOH–H_2O + 10% (w/v) $CaCl_2$ % decrease	98% w/w H.COOH–H_2O + 2% (w/v) $CaCl_2$ $[\eta]$	98% w/w H.COOH–H_2O + 2% (w/v) $CaCl_2$ % decrease
0·5	1·48	—	1·83	—	1·65	—	2·04	—
2·0	0·85	42·6	1·42	22·4	1·56	5·5	1·98	2·9
5·0	0·44	70·3	0·92	49·7	1·47	10·9	1·88	7·8
25	0·08	94·6	0·15	91·8	1·08	34·6	1·40	31·4

Upon dilution with water, followed by vigorous agitation, the silk is precipitated from formic acid – calcium chloride solutions as a white curd. Alternatively, the silk may be obtained as a film by spreading the solution on a glass plate, allowing the solvent to evaporate in a desiccator over solid sodium hydroxide, followed by washing with ethyl alcohol to remove calcium chloride.

Infra-red absorption curves of the material precipitated by water show it to be in the β-configuration. It is of interest, however, that films cast from formic acid – calcium chloride, without removal of the salt show a carbonyl peak characteristic of the α-form of silk, although other features of the spectrum are rather obscure.

We thank Mr. G. J. Weston, of this Department, for the infra-red examination of these materials.

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[1] Schurz, J., *Nature*, **173**, 952 (1954).
[2] von Veimarn, P. P., Rept. Imp. Indust. Res. Inst. Osaka, Japan **7**, 5 (1926).
[3] I.G. Farbenindustrie, B.P. 394,212 (1933).
[4] Signer, R., and Glanzmann, R., *Makromol. Chem.*, **5**, 257 (1950).
[5] Ambrose, E. J., *Nature*, **167**, 264 (1951).

Inhibition of Vernalization in *Linum usitatissimum* Linn. by Certain Synthetic Hormones

The present communication summarizes the results of eight hours prechilling soaking treatment at room temperature with different concentrations (500, 50, 5, 0·5, 0·05 and 0·005 parts per million in distilled water) of α-naphthaleneacetic acid, indolylbutyric acid and indolylacetic acid on the process of vernalization in *Linum usitatissimum* Linn., strain 477–3/2. Soaked seeds from each treatment were spread over cloth moistened with a solution of the same strength or with water and kept in Petri dishes inside a refrigerator, maintained at a temperature of 4–8° C. Mucilage on the seed-coat retained the solutions during the entire period of chilling (24 days), and this ensured a continuous supply of hormones to the embryo.

Only sprouted seeds of similar stages of development were used for sowings along with water-treated unvernalized seeds. Date of opening of the first flower on each individual plant was recorded, and the average number of days taken from date of sowing

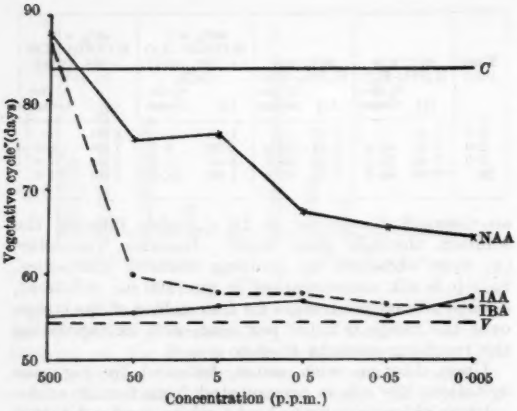

Fig. 1. Vegetative cycles of plants raised from *Linum* seeds treated with different concentrations of hormones before chilling. *C*, control; NAA, α-naphthaleneacetic acid; IAA, indolylacetic acid; IBA, indolylbutyric acid; *V*, vernalized

to anthesis for each treatment was calculated. This has been termed the vegetative cycle. The statistical validity of the experiment was determined by analysis of variance.

Of the three hormones, α-naphthaleneacetic acid was found to be the most effective, at all the concentrations, in reducing the period of earliness in flowering (Fig. 1 and Table 1). This delaying effect is directly proportional to the strength, since it brings down the earliness of 29·9 days, recorded in plants raised from water-soaked vernalized seeds, to 19·6 days at the lowest and to − 3·7 days at the highest concentration. In plants raised from seeds treated with 500 p.p.m. of this hormone, there is not only a complete inhibition of flowering induced by vernalization, but also a delay of 3·7 days, which is significant at the 5 per cent level.

Table 1. Effect of Prechilling Treatments of *Linum* Seeds with Different Concentrations of Hormones on the Vegetative Cycle of Plants Raised from Them
Date of sowing: October 17, 1953

	α-Naphthalene-acetic acid		Indolylbutyric acid		Indolylacetic acid	
Conc. (p.p.m.)	Veg. cycle in days	Delay over vernalized	Veg. cycle in days	Delay over vernalized	Veg. cycle in days	Delay over vernalized
0·005	64·6 (15)	10·3*	56·6 (27)	2·3	57·5 (13)	3·2
0·05	65·8 (14)	11·5*	56·7 (18)	2·4	55·3 (18)	1·0
0·5	67·6 (7)	13·3*	60·0 (10)	5·7*	57·1 (16)	2·8
5·0	76·5 (6)	22·2*	57·8 (19)	3·5†	56·4 (10)	2·1
50·0	75·7 (7)	21·4*	59·9 (15)	5·6*	55·6 (18)	1·3
500·0	87·9 (20)	33·6*	87·1 (21)	22·8*	54·9 (24)	0·6
Untreated vernalized			54·3 (21)	—		
Control			84·2 (29)	29·9*		

Figures in brackets indicate number of plants.
* Significant at 1 per cent level.
† Significant at 5 per cent level.
Error mean square = 29·5.

Indolylbutyric acid in the highest concentration brings about a complete nullification of the chilling effect. Vegetative cycles of plants raised from seeds treated with 50, 5 and 0·5 p.p.m. of this hormone are slightly higher than that of the normal vernalized plants and these differences are statistically significant. The same cycles do not differ significantly in plants from seeds treated with the lower concentrations (0·05 and 0·005 p.p.m.). Similar results were obtained with all the concentrations of indolylacetic acid.

Destruction of photoperiodic effects, in certain plants, through the application of synthetic hormones, is now established. But with the exception of that of Wittwer[1] and Pillai[2], there are few observations on the effect of growth substances on the process of vernalization. Wittwer[1] recorded that treatment of lettuce seeds with dichlorophenoxyacetic acid (2,4-D) during the process of chilling resulted in an inhibition of flowering induced by vernalization. Pillai[2] observed a significant decrease in earliness in flowering in *Brassica campestris* L. through a pre-vernalization soaking of seeds in 50–0·005 p.p.m. of dichlorophenoxyacetic acid.

I have suggested earlier[3] that the substance or substances formed during chilling are not direct flower-forming ones and thus differ from those synthesized in the leaves during a photoperiodic treatment. Similarity of action of certain hormones on the nullification of photoperiodic and vernalization effects, however, indicates that the above conclusion is true of the final product of vernalization only, and there is every likelihood of the existence of an intermediate step common to both vernalization and photoperiodism in the chain of reactions leading to the ultimate induction of earliness in flowering.

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[1] Wittwer, S. H., Abs. Amer. Soc. Plant Physiol. Columbus, Ohio, Meeting, 5 (1950).
[2] Pillai, V. N. K., M.Sc. thesis of the University of Agra (1954).
[3] Chakravarti, S. C., *Ind. J. Agric. Sci.*, **23**, 289 (1953); *Nature*, **173**, 407 (1954).

Relation between Vitamin D and Vitamin B_{12}

In some experiments on chick growth with wholly vegetable diets[1] supplemented with pure vitamin B_{12}, a relationship became evident between the growth-stimulating effect of this vitamin and the content of calcium, iron and vitamin D of the diet. In an attempt to elucidate the relation between the vitamin D and vitamin B_{12}, the present experiment was started.

Day-old White Leghorn chicks from non-depleted hens were, during their first week, given a wholly vegetable diet (207 in Table 1), without added vitamin D. Then they were weighed and according to their weight grouped in six equal groups, each consisting of four sub-groups with nine chicks. They were fed the same diet with different vitamin D and vitamin B_{12} supplements. The experimental period lasted three weeks, and the results are given together with the experimental plan in Table 2.

Table 1. Percentage Composition of Experimental Diet 207

Barley	22·3
Oats	14·9
Wheat bran	11·0
Corn meal	15·1
Soybean oil meal	16·6
Sunflower seed meal	10·5
Alfalfa meal	4·0
B-vitamin conc.*	1·0
Bone meal	2·0
Ground limestone	1·6
Salt mixture†	1·0
	100·0

* Minimum 200 mgm. riboflavin, 200 mgm. niacin and 20,000 I.U. thiamin per kgm.
† 896 gm. iodized NaCl (5 mgm. KI per kgm.), 50 gm. $MnSO_4.4H_2O$, 50 gm. $FeSO_4.7H_2O$, 4 gm. $CoSO_4.7H_2O$.

Table 2. CHICK GROWTH AND FEED CONSUMED PER UNIT GAIN (UNTIL FOUR WEEKS OF AGE)

Group No.	Vitamin D supplement: Cod liver oil* %	Vitamin D supplement: Deltafor D_3—400† %	Vitamin D supplement: Approx. I.U. per kgm. diet	Vitamin B_{12} (μgm. per kgm. diet)	Gain‡: abs. (gm.)	Gain‡: rel. %	Feed per kgm. gain (kgm.)
1	0	0·05	200	0	128	100	3·06
2	0	0·05	200	30	134	105	3·01
3	0·4	0·1	640	0	110	86	3·45
4	0·4	0·1	640	30	141	110	3·03
5	0·4	0·3	1,400	0	106	83	3·29
6	0·4	0·3	1,400	30	144	112	3·04

* 1,000 I.U. vitamin A, 60 I.U. vitamin D per gm.
† 400 I.U. vitamin D_3 per gm.
‡ Gain between one and four weeks, average males–females.

From this table it is evident that the two higher vitamin D supplements had significant growth-depressing effects in the groups with no vitamin B_{12}. Supplementing the diet with vitamin B_{12}, however, eliminated these effects.

Details of this and other experiments in this series will be published elsewhere.

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[1] Frölich, A., *Nature*, **173**, 132 (1954).

Deoxyribonucleoproteins of Cell Nuclei: Sensitivity to X-Rays

STUDIES of aqueous systems of intact deoxyribonucleoproteins[1] showed that they were markedly unstable. Storage at 2°–5° C. for 24–36 hr. produced a substantial depolymerization of the deoxyribonucleic acid component. This is in marked contrast to the stability of dissociated nucleoproteins in 1·0 *M* sodium chloride. It was felt that this instability might be functionally significant in the mechanism of radiation effects on biological systems. Studies were therefore made of the effects of X-radiation on aqueous nucleoprotein gels.

When isolated calf-thymus nuclei are placed in water, there is a rapid gelation, an increase in volume, and lysis of the nuclei. Further additions of water produce a further increase in the volume of the gel, a concomitant decrease in rigidity, and eventually an aqueous nucleoprotein solution. Such gels have a high and anomalous viscosity and are very susceptible to degradation, losing viscosity rapidly at 25°, more slowly at 2°–5° C. When they are exposed to low doses of X-rays no immediate effect is apparent. After 4–6 hr. storage of the irradiated gel at 2°–5° C., there is an acceleration of the spontaneous loss of viscosity. The effect is proportional to dose in the range studied (250–5,000 r.).

The observed effect is a decrease in the structural viscosity of the nucleoprotein gel and relates to the interactions between deoxyribonucleoprotein molecules. In 1·0 *M* sodium chloride, the structural viscosity of the nucleoprotein gel is abolished, and the nucleic acids and proteins are dissociated. Under these conditions it is possible to measure the intrinsic viscosity of the deoxyribonucleic acid. The doses of X-radiation used had no effect on the intrinsic viscosity of the deoxyribonucleic acid, whereas the spontaneous loss of viscosity of non-irradiated gels involves depolymerization and a decrease of intrinsic viscosity.

Exposure of isolated nuclei to 1,000 r. of X-rays markedly decreases the capacity of these nuclei to swell when placed in water. This is in agreement with previous observations[2] that X-rays inhibit trypsin-induced swelling in salivary glands of *Drosophila* larvæ.

With regard to the loss of viscosity observed in the nucleoprotein gels, there are apparently at least two separate factors involved. The lack of any immediate effect of X-radiation on the gel or on its deoxyribonucleic acid component strongly suggests that the observed phenomena involve primarily the interactions of the protein moieties of these systems. Further details of this work will be published in due course.

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[1] Bernstein, M. H., and Mazia, D., *Biochim. Biophys. Acta*, **10**, 600 (1953); **11**, 59 (1953).
[2] Kaufmann, B. P., *et al.*, Carnegie Institution of Washington Year Book No. 50, 203 (1951).

Analysis of Unordered Tetrads Segregating for a Lethal or Other Epistatic Factor

Perkins[1] and Whitehouse[2] have shown how chromosome centromeres can be mapped by the analysis of unordered tetrads of spores (or gametes), provided segregation is occurring at three unlinked loci. The basis of the method is the determination of the frequency of tetratype tetrads for the loci considered in pairs. If at one of the three loci there is segregation for a lethal or other epistatic factor, the frequency of tetratype tetrads with respect to the other two loci will be indeterminable. Nevertheless, it is still possible to map the genes in relation to their centromeres.

Consider first the general case of tetrads segregating for three pairs of unlinked genes, *A* and *a*, *B* and *b* and *C* and *c*. Five classes of tetrads can be recognized:

Class	Genotype of tetrad	Ditype (*D*) or tetratype (*T*): *A* and *B*	*A* and *C*	*B* and *C*
I	*ABC abc* / *ABc abC* / *AbC aBc* / *Abc aBC* and *ABC abc* / *ABc abC* / *AbC aBc* / *Abc aBC*	*D*	*D*	*D*
II	*ABc abC* / *Abc aBC* and *ABC abc* / *AbC aBc*	*D*	*T*	*T*
III	*ABC abc* / *ABc abC* and *AbC aBc* / *Abc aBC*	*T*	*D*	*T*
IV	*ABC abc* / *ABc abC* and *Abc aBC* / *AbC aBc*	*T*	*T*	*D*
V	*ABc abc* / *ABC abC* and *AbC aBC* / *Abc aBc*	*T*	*T*	*T*

Tetrads of class I are ditype with respect to all three combinations of the loci in pairs. As indicated, there are four possible constitutions for this type of

tetrad, depending on whether the pairs of factors show the parental combination or whether some show recombination. However, if the three loci are unlinked, these four sub-classes are expected with equal frequency. Tetrads of classes II, III and IV are ditype with respect to one pair of loci, tetratype with respect to the other two. In each instance, there are two sub-classes, one with the ditype pair in the parental combination and the other non-parental, and again these are expected with equal frequency. Tetrads of class V are tetratype with respect to all three combinations of the loci in pairs.

Segregation at the first division of meiosis for all three loci will give rise only to class I tetrads. Segregation at the first division at two loci and at the second division at the third locus will give rise to either class II or class III or class IV tetrads, depending on which locus shows second division segregation. Segregation at the first division at one locus and at the second division at the other two will give rise with equal frequency to class V tetrads and to either class II or class III or class IV tetrads, depending on which locus shows first division segregation. Segregation at the second division for all three loci will give rise to classes I, II, III and IV with equal frequency. Expressed algebraically, if the frequencies of segregation at the second division of meiosis for the three loci A, B and C are x, y and z respectively, the frequencies of segregation at the first division being $1-x$, $1-y$ and $1-z$, respectively, then the frequencies of the five classes of tetrads are as follows:

Class	Frequency
I	$(1-x)(1-y)(1-z) + \frac{xyz}{4}$
II	$x(1-x)(1-y) + \frac{xy(1-z)}{2} + \frac{xyz}{4}$
III	$y(1-x)(1-z) + \frac{xz(1-y)}{2} + \frac{xyz}{4}$
IV	$x(1-y)(1-z) + \frac{yz(1-x)}{2} + \frac{xyz}{4}$
V	$\frac{xy(1-z)}{2} + \frac{xz(1-y)}{2} + \frac{yz(1-x)}{2}$

Now, if A is a lethal or other epistatic factor, suppressing the difference in phenotype of one or both of the other pairs of factors, then classes IV and V cannot be distinguished from one another; but they can be separated collectively from the other three classes (I, II and III), which can also be distinguished from each other. If p, q and r are the observed frequencies (as fractions of the total tetrads) of classes I, II and III, respectively, then we have three simultaneous equations for x, y and z. The solutions to these equations are as follows:

$$x = \frac{-b \pm \sqrt{b^2-4ac}}{2a},$$

where

$$a = 3(p-q-r) + 1,$$
$$b = 3[(p+q)(p+r) - 2p + q + r] - 1,$$
$$c = 4[p-(p+q)(p+r)],$$
$$y = \frac{2(x+p+q-1)}{3x-2},$$
$$z = \frac{2(x+p+r-1)}{3x-2}.$$

As an example of the use of these formulæ, Hartshorne[3] has analysed ninety-two tetrads of *Chlamydomonas reinhardi* segregating for three unlinked factors: 'eyeless' (*ey*), mating-type (*mt*) and 'small colony' (*sc*). The 'small colony' character is suppressed in the presence of the normal allele of 'eyeless'. In the analysis above, A is the epistatic locus and must therefore be equated with *ey*. Let *mt* equal B and *sc* equal C. The frequencies observed by Hartshorne for the different classes of tetrads are then as follows:

Class	I	II	III	IV+V	Total
Frequency	2	9	6	75	92

Hence

$$p = \frac{2}{92}, \quad q = \frac{9}{92}, \quad r = \frac{6}{92},$$

and, applying the formulæ, we obtain either

$$x(ey) = 0{\cdot}979, \quad y(mt) = 0{\cdot}210, \quad z(sc) = 0{\cdot}140,$$

or

$$x(ey) = 0{\cdot}080, \quad y(mt) = 0{\cdot}910, \quad z(sc) = 0{\cdot}947.$$

Further data make it possible to discriminate between these two alternatives. Hartshorne analysed 151 tetrads segregating for *ey* and the unlinked character 'slow growth' (*sg*), and found 9, or 5·96 per cent, were tetratype. This indicates that both these factors are situated close to their centromeres. Hence, the second of the above alternatives is the true one. It is concluded that the second division segregation frequencies for *ey*, *mt* and *sc* are 8·0, 91·0 and 94·7 per cent, respectively, and the genes are located 4·0, 45·5 and 47·3 units from their respective centromeres.

Papazian[4] and Spiegelman[5] have pointed out that the simple procedure of halving the second division segregation frequency to obtain the map distance of a locus from its centromere is inaccurate unless the map distance is short. However, their correcting formula is inapplicable to second division segregation frequencies in excess of 2/3, such as those for *mt* and *sc* above. It appears impossible to correct accurately map distances obtained from second division segregation frequencies, except by the study of intervening loci. Thus, a second division segregation frequency of nearly 100 per cent implies that one cross-over is occurring proximal to the locus in question at nearly every meiosis, that is, that double cross-overs are rare, and hence that the map distance is approximately half this frequency. On the other hand, a second division segregation frequency of about 67 per cent may mean that one cross-over proximal to the locus is occurring in two-thirds of meioses and hence a map distance of 33 units is correct, or it may mean that several cross-overs proximal to the locus are occurring at every meiosis, and hence that the map distance between locus and centromere is perhaps 150 or 200 units. It is convenient to retain the customary procedure of halving the second division segregation frequency to obtain an estimate of the map distance from the centromere, while remembering the limitations of the method.

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[1] Perkins, D. D., *Genetics*, **34**, 607 (1949).
[2] Whitehouse, H. L. K., *Nature*, **165**, 893 (1950).
[3] Hartshorne, J. N., Ph.D. thesis, Cambridge University (1953).
[4] Papazian, H. P., *Genetics*, **36**, 441 (1951).
[5] Spiegelman, S., *Science*, **116**, 510 (1952).

A New Antibacterial Principle : Megacine

In the course of an investigation of the potential lysogenic powers of *B. megaterium* strains isolated recently from fæcal and soil samples, one of the strains studied (No. 216) showed a particular effect. When a highly diluted broth culture of this strain was mixed with a heavy suspension of a phage-sensitive *B. megaterium* strain ('mutilate'), and plated on yeast extract agar containing casein hydrolysate, no phage plaques were seen, but the colonies of the strain 216 were surrounded by a small clear halo. To study this effect, young aerated cultures of the strain grown in yeast extract – casein hydrolysate broth were lightly irradiated with ultra-violet light and reincubated. The turbidity of these cultures increased after irradiation up to the end of the second hour; then a lysis of the bacteria set in, which became almost complete in three hours. The bacterial lysate thus obtained does not contain phage particles when tested in the usual way. On the other hand, if one drop of various dilutions (up to a few thousands) of the lysate was put on the surface of a yeast extract – casein hydrolysate agar plate heavily seeded with *B. megaterium*, it caused a clear spot with no bacterial growth on the site of the drops. There was no reproduction of the antibacterial principle (which we propose to call 'megacine') in the sensitive bacteria, which fact excludes its phage character.

The lysates obtained by irradiation of young growing cultures containing approximately 10^7 cells/ml. were active up to dilutions of 10^{-3}–10^{-4}, depending on the *B. megaterium* strains used as test organism. All the thirty-seven strains of *B. megaterium* investigated, whether lysogenic or not, were sensitive to the antibacterial principle. The most striking was that the producer, the strain 216, was also sensitive to the principle, though to a lesser degree (10^{-2} dilution) than the others. On the other hand, when a considerable number of strains belonging to various other species of bacteria were tested, none of them was found to be sensitive to megacine. The figures in parenthesis show the number of strains investigated : *E. coli* (8), different *Salmonellae* (10), *Shigellae* (4), *Ps. aeruginosa* (3), *Proteus X*-19 (1), *Proteus morgani* (1), *Ae. aerogenes* (1), *Serratia mercescens* (1), *Micrococcus pyogenes*, var. *aureus* (4), var. *albus* (7), *M. tetragenus* (1), *Sarcina flava* (4), *Diplococcus pneumoniae* types 1, 2, 3, 14 (7), *Str. viridans* (1), *Str. faecalis* (3), *Str. haemolyticus A, B, C* (15), *C. diphtheriae* (1), *C. xerosis* (1), *B. anthracis* (8), *B. cereus* (6), *B. subtilis* (7). All the strains of *Sarcina flava* investigated were, however, sensitive to lysozyme, which fact indicates the dissimilarity in the mode of action of lysozyme and megacine. The principle is very slightly diffusible in agar, does not pass through parchment and is moderately thermolabile. Ninety per cent of its activity is destroyed at 80° C. in 30 min., although heating at 60° did not diminish its antibacterial effect. The principle was precipitated by ammonium sulphate at 75 per cent saturation. Trypsin inactivated the active principle.

Megacine is lethal for the cells of *B. megaterium*. If it is added to a light suspension of this bacillus, the organisms are killed within minutes and partly lysed by the fifth to sixth hour. It cannot be classed as an antibiotic, for its characteristics are more closely related to the bacteriocines[1], which are represented so far by colicines[2] and pyocine[3]. There is, however, a striking difference between megacine and these antibacterial principles, namely, both pyocine and colicines are bactericidal only for certain strains of their own or related species, and the strains producing the principles are not sensitive to their own bactericine. The unique feature of megacine lies in its effect on the very strain which produces it.

Full details of these observations will be published in the *Acta Microbiologica Hungarica*.

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[1] Jacob, F., Lwoff, A., Simonovitch, A., and Wollmann, E., *Ann. Inst. Pasteur*, **84**, 222 (1953).
[2] Gratia, A., *C.R. Soc. Biol.*, **93**, 1040 (1925). Heatley, N. G., and Florey, H. W., *Brit. J. Exp. Path.*, **27**, 378 (1947). Fredericq, P. *Ann. Inst. Pasteur*, **84**, 294 (1953). Jacob, F., Simonovitch, L., and Wollmann, E., *Ann. Inst. Pasteur*, **83**, 295 (1952).
[3] Jacob, F., *Ann. Inst. Pasteur*, **86**, 149 (1954).

Sensitive Parallax Detector for Optical Bench

In accurate measurements of focal-lengths and the like, on an optical bench, it is customary to employ the points of pins mounted on adjustable stands. The lens under test has itself to be so mounted as to enable it and the pin-points to be 'lined up' parallel to the tracks of the optical bench. This is a somewhat troublesome and time-consuming operation, and distracts the students' attention from the basic aim of the experiment. The device herein described eliminates much of this tedious procedure and can indeed yield more accurate settings than the older procedure. As it is easily adaptable to any type of optical bench, I will confine myself to describing the details peculiar to the device itself.

A 'herring bone' pattern, such as that shown in Fig. 1, consists of some two dozen parallel lines which interact an equal number of parallel lines inclined at an angle of 175° to the first set. This is reproduced photographically on lantern slides. As finished, the slides show a pattern of intensely black lines spaced about 3 mm. apart and about 0·1 mm. thick, on a clear background. Of course, the slides are covered with clear glass and bound as usual.

These slides are clamped with spring clips on brackets mounted on the stands which slide on the optical bench. No precise centering is required ; all that is necessary is that the plane of the slide shall be normal to the bench axis, and that the middles

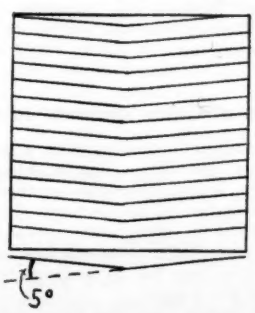

Fig. 1. Graticule pattern. The number of lines is fewer and the angle of inclination exaggerated for reasons of clarity

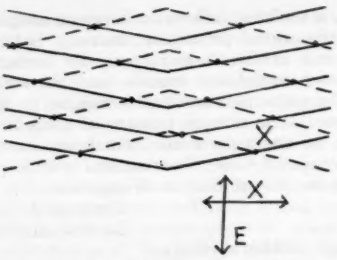

Fig. 2. Part of the pattern presented to the eye. It should be noticed that the points of the two 'herring bone' patterns do not necessarily coincide. *E,X* indicate the movement of the eye and the consequent sideways displacement of the intersections *X*

of the slides shall be roughly in line with the centre of the lens. The lens holder need not be adjustable; simple V-blocks are sufficient.

One of these slides is illuminated from behind by diffused light, and a real inverted image of its pattern is found by the lens under test in the vicinity of the other (graticule). On looking at this second graticule in the direction of the lens, the pattern of the image and the graticule appears somewhat like Fig. 2, where the dotted lines represent the image and the full lines the graticule. If the image is not in the same plane as the graticule, slight transverse movements of the eye cause the intersections (X) to shift sideways. The graticule is then moved along the bench towards or away from this position until this shifting effect disappears. The image is now in the plane of the graticule. The lines are inclined at an angle, and it is easy to show that the lateral shift of an intersection X is greater than the lateral 'parallax' displacement observed in the ordinary way in the ratio $1/a$, where a is the acute angle in radians between the two sets of lines. Thus, in our case the ratio is about $57°/5° = 11:1$. Thus the sensitivity is about tenfold greater than that of the older method.

When measuring the focal length of a concave mirror, or fixing the focal point of a lens system using a plane mirror behind the lens, one half of the screen is illuminated and the setting made by viewing the (reflected) image on the other half. The pattern viewed is then similar to that described.

The device lends itself to the study of the curvature of the image, to spherical aberration and to other effects. Its main advantages are its sensitivity and ease of adjustment, and that it enables a form of optical bench to be constructed which, although inexpensive, is capable of considerable accuracy.

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Occurrence of *Culex simpsoni* in Mauritius

During a survey of breeding sites, a mosquito new to Mauritius has been found. Larvæ of *Culex simpsoni* Theobald were found breeding profusely in rock pools in the river bed of the Tamarin Gorges. In the same pool, larvæ of *Anopheles gambiae*, *Anopheles maculipalpis* and *Culex tritaeniorhyncus* were also found. The pool was fed by seepage from a spring on the side of the gorge.

MacGregor[1] stated that the larvæ of *C. simpsoni* were pale green in colour during life; this cannot be confirmed. The larvæ and pupæ obtained from the Tamarin Gorges were light blue in colour during life, changing to pale green at death.

C. simpsoni has not previously been reported from Mauritius; but in Rodrigues, another island of the Mascarene Group, it is a common insect. It is a moot point whether Mauritius has been invaded from Rodrigues, or whether *simpsoni* is native to Mauritius, and has remained undetected due to the unfrequented and almost inaccessible siting of its breeding place. Rodrigues is, geologically, the older island; but its limited mosquito fauna (*C. fatigans*, *Ae. aegypti*, *C. simpsoni*), when contrasted with the relative luxuriant mosquito fauna of Mauritius, would suggest that it is native to Mauritius. *C. simpsoni* has not been detected in the French island of Réunion, the third and youngest island of the Mascarene Group.

It is of interest to note that the surface of the breeding pool supported both *Symphypleona* and *Arthropleona* of the order *Collembola*—an order of insects not previously recorded from Mauritius.

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[1] MacGregor, M. E., "Mosquito Surveys" (London, 1927).

Paper Chromatography of Organic Acids

Glyconic acids, glycaric acids and glycuronic acids and certain related hydroxy acids show a marked tendency to produce streaked spots on paper chromatograms. This may be eliminated by incorporating in the developing solvent certain organic acids such as formic acid or acetic acid[1] to suppress ionization of the carboxyl group. The developing solvents incorporating formic or acetic acid vary in composition with time, due to slow esterification of the acid when an alcohol is present; for this reason R_F values are variable. Moreover, the number of suitable acidic developing solvents is limited. In order to be able to use any developing solvent for the separation of acids, we have coated the filter paper with alginic acid. Whatman No. 1 filter paper is dipped into a 1 per cent aqueous ammonium alginate solution and after removing the excess of this solution the paper is dipped into N hydrochloric acid which causes precipitation of alginic acid. The paper so treated is washed with water or ethanol to remove excess hydrochloric acid and allowed to dry in the air.

Papers prepared in this way have been used for partition chromatography of D-mannuronic acid, D-glucuronic acid, D-galacturonic acid, citric acid, tartaric acid, succinic acid, malic acid, glycollic acid, malonic acid and various aldobiuronic acids such as O-D-glucopyranosidurono-(1 → 2)-α-D-xylopyranose isolated from chagual gum[2].

Since the papers are acidic in character, the usual acid-base indicators could not be used for detecting the acids. The alginic acid, however, did not interfere with the detection of uronic acids and certain hydroxy acids such as citric, tartaric and malic acids by the ammoniacal silver nitrate reagent. The uronic acids could also be detected on alginic acid papers by the spray reagents containing aromatic amines such as aniline, *p*-anisidine, etc., usually employed for locating reducing sugars.

The mono- and di-carboxylic acids which could not be detected by the silver nitrate and amine sprays were located by first spraying the papers with a 50 per cent aqueous alcoholic solution containing 5 per cent of an amine (for example, aniline or *p*-anisidine) and 5 per cent sodium nitrite, and then spraying soon afterwards with an alkaline solution of either a phenol (for example, β-naphthol) or an aromatic amine (β-naphthylamine, 6,8-disulphonic acid). The acids are located by the appearance of colours due to azo-dye formation. When these sprayed chromatograms are dry, they exhibit a strong background fluorescence upon which the dark non-fluorescing azo-dye spots could readily be detected; this is particularly noticeable when an amine is used as the coupling agent.

The acids could also be detected by making use of a browning reaction catalysed by acids. When the chromatograms are sprayed with a 50 per cent aqueous alcoholic solution containing 5 per cent of an aromatic amine (for example, aniline or *p*-anisidine) and 5 per cent of a reducing sugar (D-xylose is preferred) and heated for a short time at 125–130° C., brown spots appear wherever acids are present.

F. Smith
D. Spriestersbach

University of Minnesota,
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U.S.A.
June 6.

[1] Lugg, J. W. H., and Overell, B. T., *Aust. J. Sci. Res., Phys. Sci.*, 1, 98 (1948). Buchanan, J. G., Decker, C. A., and Long, A. G., *J. Chem. Soc.*, 3162 (1950). Howard, G., and Martin, A. J. P., *Biochem. J.*, **46**, 532 (1950). Partridge, S. M., *Biochem. J.*, **42**, 238 (1948). Buch, M. L., Montgomery, R., and Porter, W. L., *Anal. Chem.*, **24**, 489 (1952).

[2] Hamilton, J. K., Smith, F., and Spriestersbach, D. (unpublished work).

Estimation of Impurities in Liquid Chlorine by Infra-red Absorption Spectrophotometry

The method of E. R. Wright and R. A. Smith[1] for the determination of moisture in liquid chlorine by infra-red absorption spectrophotometry has been extended to include impurities that give absorption bands as far as 1,180 cm.$^{-1}$ (8·5 μ). In the range 4,000–1,180 cm.$^{-1}$, liquid chlorine is, for practical purposes, completely transparent in the infra-red. This enables the use of path-lengths a thousand times greater than normal. Certain impurities can thus be estimated to a few parts per million by this method.

A 5·25-cm. tantalum-clad steel pressure cel (200 lb./sq. in.) was fitted with calcium fluoride windows and 'Teflon' gaskets. This cell was designed and made by the Perkin Elmer Corporation (Norwalk, Connecticut). It was fitted with stainless-steel needle valves and a stainless-steel reservoir which enabled the cell to be filled under pressure directly from an inverted chlorine cylinder, or placed in a Dewar flask and surrounded by solid carbon dioxide for filling at atmospheric pressure. Spectra were recorded on a Perkin Elmer Model 12*C* single-beam instrument fitted with a calcium fluoride prism to give adequate resolution.

The concentration of impurity is given by the Beer's law relationship which (adopting the usual symbols) is as follows:

$$c = \frac{1}{E_\lambda l} \log\left(\frac{I_0}{I}\right) \text{max.}$$

Using standardized conditions, the concentration in parts per million can be expressed as a constant times the optical density, which is read directly from the absorption curve.

The method has been evaluated by adding weighed amounts of the following compounds to liquid chlorine (wave numbers of absorption bands in cm.$^{-1}$ given in parentheses): chloroform (1,213), methylene chloride (1,259), hexachlorobenzene (1,348). For these compounds, and at the path-length used, this method is sensitive to approximately 5 p.p.m. with an accuracy at 50 p.p.m. of ± 10 per cent.

The method has been used for the estimation of moisture in liquid chlorine using the absorption band at 1,640 cm.$^{-1}$ which is free from interference by carbon dioxide.

This work is being submitted for publication more fully elsewhere. So far as we know, this is the first account of infra-red absorption spectrophotometry of liquid chlorine from 2,860 cm.$^{-1}$ to 1,180 cm.$^{-1}$ (3·5–8 5 μ).

The constant help and advice of F. W. Matthews of this laboratory is gratefully acknowledged, and the Perkin Elmer Corporation is thanked for the loan of the cell.

A. W. Pross

Central Research Laboratory,
Canadian Industries, Ltd.,
McMasterville, Quebec.
April 23.

[1] Wright, E. R., and Smith, R. A., American Chemical Society Meeting, Buffalo, N.Y. (March 1952).

Production of Individual, Sized, Droplets by High-Voltage 'Firing' from a Micropipette

There are several satisfactory methods for the continuous production of uniform droplets. The range below 10 microns may be covered in the La Mer vapour condensation apparatus, 10 μ–1,000 μ, by the spinning disk principle, 100 μ to several millimetres by the vibrating tip, interrupted jet and microburette principles and 800 μ to 6–7 mm. by liquid falling by gravity from the tip of a vertical tube.

In experiments on the evaporation-rates of various airborne droplets, we wished to produce individual droplets and place them with accuracy in the field of the microscope, for example, on a 1-μ diameter wire. Of the above methods, only the last is suitable for producing individual drops; but these are much too large for our purpose. The size of drops falling by gravity from a fine tip is given with reasonable accuracy by equating the upward force of surface tension acting round the circumference of the tip to the gravitational pull at the moment of breakaway: $\pi d.T = \pi D^3 \rho g/6$, where d and D are the diameters of the tip and droplet respectively. For a 20-μ tip, the diameter of the drop which falls is still as large as 0·95 mm. The cubic relationship between d and D prohibits any further worth-while reduction in D as d is reduced to the smallest practical size.

We have found that droplets of any desired size down to about 10 μ may be 'fired' off from the tip of a micropipette by applying a momentary high voltage to the liquid. Suitable micropipettes in thin-walled glass tubing may be drawn by hand; but much greater precision, particularly in the finer sizes, is given by a 'microforge' such as Powell's microscope attachment[1]. The micropipette needle is fitted to a

small glass holder which has (i) a sealed-in wire electrode passing up inside the needle to make contact with the liquid, and (ii) a small side arm for supplying pneumatic pressure to the needle from a hand-operated hypodermic syringe via a length of fine rubber tubing. A source of d.c. voltage variable between 0 and 5 kV. is required, and it is convenient to apply this to the micropipette by means of a bell-push operated relay. For mounting the micropipette in its operating position, Goldacre's arrangement[2] is convenient because of its simplicity, universal adjustment and high insulation.

When forming droplets, the procedure is to apply pneumatic pressure to the micropipette, observing the drop in a microscope fitted with a calibrated scale in the eyepiece. As the drop is formed, it tends to run back up the shaft of the pipette so that the liquid usually cannot be sucked back if the required size is exceeded; however, evaporation will quickly reduce the drop to the required diameter, with most liquids. When the drop is exactly the required size, the bell-push is operated, the drop flies off and, by trial and error setting of the micropipette, may be aimed with considerable accuracy over a distance of several centimetres. The trajectory of the charged droplet is of course strongly influenced by electrostatic fields. A 100-megohm leak to earth from the electrode ensures discharge of the holder before the next drop is formed.

A study was made of the minimum firing voltage, tip diameter and drop size for various liquids with the view of establishing a relationship between the relevant parameters; but there was too much unexplained variability in the results for this to be done. It is possible that such factors as the cleanliness of the outside of the pipette and the shape and taper of the tip may have an overriding effect. The results showed a general correlation between a slow increase in minimum firing voltage and increasing tip diameter, the former being practically independent of size of drop from a given tip. In practice, it is convenient to work at a voltage of about twice the minimum firing voltage to ensure immediate firing of the drop. There is a considerable range above the minimum firing voltage which can be used; but at too high a figure the drop is disrupted and spraying commences. Observed minimum firing voltages for various tips are: $< 10\,\mu$, 0·6–1·3 kV.; 10–20 μ, 0·8–1·4 kV.; 20–50 μ, 1·0–1·8 kV.; 50–100 μ, 1·5–3·0 kV. These figures cover all liquids, from conductors such as aqueous salt solutions to insulators such as paraffin oil. The minimum firing voltages for water may be reduced considerably below these values by coating the outer surface of the pipette with a thin film of paraffin wax.

The rule-of-thumb for pipette size is that the tip should not exceed one-third of the required droplet diameter. Micropipettes down to 1–2 μ are easily made, though blockage from foreign substances in the liquid naturally becomes a problem with such fine tubes. To minimize the tendency of the droplet to run back up the micropipette, the taper on the latter should be as small as possible. With a little practice in the control of heating, traction and position of the tube when forming the pipette in the microforge, almost parallel-sided tubes can be made.

Apart from our own requirements, other uses for individually produced droplets may be found in, for example, fuel combustion studies, applying minute quantities of toxic substances such as insecticides to specific areas on insects, the calibration of droplet detectors, etc.

It should be possible to produce droplets continuously by means of a steady liquid flow and controlled frequency voltage pulse.

Acknowledgment is made to the Chief Scientist, Ministry of Supply, for permission to publish this letter, and we are grateful to Mr. W. R. Lane for advice.

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K. R. May

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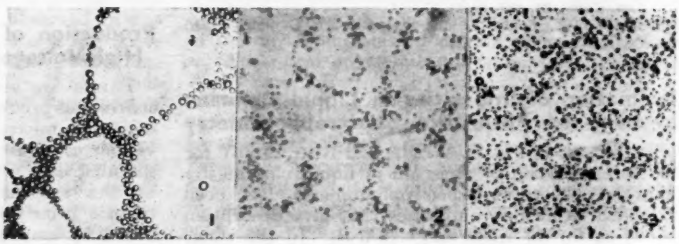
May 28.

[1] Powell, E. O., *J. Roy. Micr. Soc.*, **72**, 214 (1953).
[2] Goldacre, R. J., *Nature*, **173**, 45 (1954).

Structure of Breath Deposits on Dielectric Oils

It is possible, by low-power microscopic observation of water droplets deposited by breathing upon the surface of dielectric oils, to detect their degree of alteration by ageing.



With unused oil, the breath figures are identical with those obtained with a neutral paraffin oil containing some foreign molecules with hydrophilic groups[1]: moisture condenses on their surface as very small, randomly disposed droplets (about 10 μ in diameter). After some seconds these droplets join up, forming chains, and finally coalesce as bigger droplets located at the intersection points of former chains (Fig. 1).

With dielectric oils artificially aged (by heating for 10 hr. in contact with copper, at 120° C. or higher) droplets deposited by breathing join up as more-or-less elongated groups (Fig. 2); but they do not readily coalesce to form bigger drops.

With dielectric oil aged by being in use for a long time, the droplets do not join up at all and have the appearance shown in Fig. 3.

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[1] Mérigoux, I-R., *C.R. Acad. Sci., Paris*, **207**, 47 (1938); **208**, 1882 (1939); *Bull. Sté Fr. de Physique*, **23**, 70 (1944).

Determination of the Absolute Concentration of Deuterium in Thames River Water

THE deuterium content of natural waters has hitherto been determined either by accurate density measurements or by a mass spectrometer, absolute values being obtained by intercomparison with standard samples of known absolute deuterium concentration prepared from deuterium-free water. However, density measurements are complicated by variations in the concentrations of the more abundant oxygen-17 and oxygen-18 isotopes, and the preparation of deuterium-free water is a long procedure. These complications can be eliminated by the following simple method, using only a mass spectrometer.

A number of standard water samples are first prepared from mixtures of the natural water and pure heavy water, giving different known excess concentrations, ΔC, above the unknown absolute concentration, C_0, of deuterium in the natural water. The values of $\Delta C/C_0$ are then directly determined by the mass spectrometer, since

$$\frac{(HD/H_2)\text{std.}}{(HD/H_2)\text{nat.}} = 1 + (\Delta C/C_0),$$

where both C_0 and $\Delta C \ll 1$. Hence, by plotting $\Delta C/C_0$ against ΔC, a straight line passing through the origin should be obtained, the reciprocal of the slope giving the value of C_0.

This method was used for determining the absolute concentration of deuterium in Thames water, sampled in August 1953, no previous mass spectrometer determinations having been made for any British fresh waters. Three standard water samples were prepared by weighing, using heavy water containing 99·73 ± 0·01 per cent deuterium and only 0·02 per cent oxygen-18 in excess of its natural concentration of 0·20 per cent. Gas samples were prepared from these and from natural water by reduction[1] of 25-mgm. quantities over uranium metal turnings at 500° C. The molecular isotope abundance ratio, HD/H_2, for each of the standard samples was compared with that of the natural sample using a mass spectrometer of high stability developed from a design of Nier's[2]. The results and mean deviations are shown in Table 1 and Fig. 1.

Table 1

$C_0 = 0{\cdot}0152 \pm 0{\cdot}0003$ per cent deuterium

Sample	1	2	3
ΔC (per cent)	0·005800	0·01160	0·01740
$(\Delta C/C_0)$	0·384 ± 0·004	0·761 ± 0·002	1·140 ± 0·006

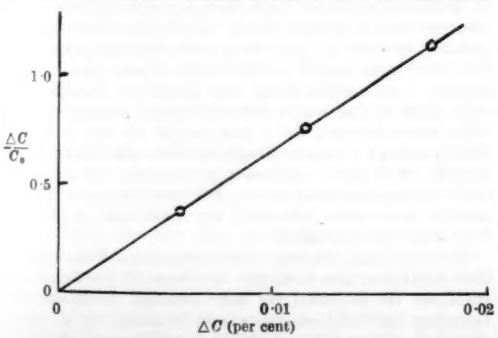

Fig. 1

The error quoted for C_0 includes the maximum possible systematic error which could have been introduced if the resistors used to measure the ion beams had not obeyed Ohm's law. Separate measurements showed that this error could not have exceeded ± 1 per cent of $\Delta C/C_0$. The normal procedure for correcting for the formation of tritium ions was used in which the effect, noted by Friedman[3], of a departure from the assumed linear relationship between the HD/H_2 ratios and the H_2 beam intensity at low values of the latter did not occur and was not therefore a source of error. The total measured memory effect between samples was − 1 per cent of $\Delta C/C_0$, for which the above results have been corrected.

Friedman's[3] recent survey of absolute deuterium concentrations, with a precision of ± 0·00002 per cent and absolute to within ± 0·0002 per cent, included values ranging from 0·0133–0·0154 per cent for a wide variety of American fresh waters, and 0·0153–0·0156 per cent for various ocean waters. Thus our absolute value for Thames water lies at the high end of the American freshwater range and near the less variable ocean values. This may be attributed to the fact that the bulk of the rainfall entering the Thames is only an initial condensed fraction of the water vapour carried inland by the prevailing Atlantic winds. The resulting deuterium enrichment on condensation then approximately cancels the original depletion (about 9 per cent at 10° C.) occurring on evaporation from the Atlantic, although there may be some further depletion before being carried inland. In contrast, for a large land mass like the United States, where a much higher proportion of the water vapour carried inland is ultimately condensed, freshwater concentrations extend well below the ocean values.

G. R. CLARKE
W. H. DENTON
P. REYNOLDS

Atomic Energy Research Establishment,
Harwell, Berks. June 15.

[1] Bigeleisen, J., Perlman, M. C., and Prosser, H. C., *Anal. Chem.*, **24**, 1356 (1952).
[2] Nier, A. O., Inghram, M. G., Stevens, C. M., and Rustad, B., "Mass Spectrometer for Routine Hydrogen Isotope Analysis", A.E.C.D., 2806, and Supp. No. 1.
[3] Friedman, I., *Geochimica et Cosmochimica Acta*, **4**, Nos. 1/2, 89 (1953).

A Deep Sounding from the Southern Hemisphere

IT is well known that the great trenches of the Western Pacific represent larger vertical departures from the level surface of the geoid than even the Himalayas. But our knowledge of the shape of the ocean floor is still so fragmentary that the question as to which trench is the deepest has received several different answers within the past two decades. The Mindanao Trench east of the Philippines was long believed to contain the greatest oceanic depth; but for a few years prior to 1950 many authorities considered that the U.S.S. *Ramapo* soundings in the Japan Trench were the deepest yet recorded. In that year Hess and Buell[1] re-examined the data and concluded that the sounding of 5,740 ± 50 fathoms obtained in the Mindanao Trench by the U.S.S. *Cape Johnson* during the Second World War represented the greatest depth. H.M.S. *Challenger* in 1951 made still deeper soundings in the Marianas Trench east of Guam. These were reported by Carruthers and Lawford[2], and later Gaskell, Swallow and Ritchie[3]

stated that the maximum depth lay between 5,882 and 5,940 fathoms.

In December–January 1952–53, during the Capricorn Expedition of the Scripps Institution of Oceanography, the research vessels *Horizon* and *Spencer F. Baird* made twenty-four echo-sounding lines across the Tonga Trench between lat. 14° 30′ S. and 26° 15′ S. *Horizon* found the area of greatest depth more than 5,500 fathoms near the abrupt change in trend of the trench axis 180 miles south of the island of Tonga Tabu. In this "Horizon Deep"[4], soundings were taken by recording the echoes from explosions in order to eliminate some of the sources of absolute error inherent in the echo-sounding apparatus. Positions were determined by dead reckoning between morning and evening star sights supplemented by meridian altitudes of the sun at noon.

As the ship proceeded at about 7·5 knots, half-pound demolition blocks with 14-in. fuses were dropped overboard at 3–10 min. intervals. The charges exploded 10–13 fathoms below the surface; the firing mark and echo-train were received on the echo-sounder hydrophone and were recorded by a pen oscillograph. Timing marks were placed on the record at 1-sec. intervals using a break-circuit chronograph. The longest time of travel for the first echo was measured at lat. 23° 15·5′ S. and long. 174° 36·5′ W.

Assuming that this echo came from directly beneath the ship, and using velocities of sound at different depths computed with the aid of Kuwahara's tables[5] from temperature and salinity measurements by *Spencer F. Baird*, 200 miles north of *Horizon's* position, the time of travel corresponds to a depth of 5,814 fathoms (10,633 m.). If this were accepted as the time value, it would be the deepest sounding yet recorded from the southern hemisphere; it would exceed the Galathea Depth in the Mindanao Trench[6] by 50 fathoms and would be second only to the soundings obtained by H.M.S. *Challenger* in the Marianas Trench.

An investigation of the uncertainties involved in the depth of explosion of the charges, in reading and correcting the records, in the timing circuit of the oscillograph, and in the computed velocities of sound, indicates that the combined error from these causes is less than ± 15 fathoms. The consistency of the travel times recorded from successive explosions shows that true sea-floor echoes were obtained. But careful comparisons of the first and subsequent echoes from each shot on the line of soundings show that the first echo at the above stated position came from the relatively gentle eastern slope of the trench, and that the actual depth directly under the ship was somewhat greater. Because of the V-shaped cross-section of the trench, a 'masked' zone extended for a distance of two miles west of the position. Here the first echoes to arrive came from the steeply sloping west wall rather than from the bottom beneath. Graphical analysis of the travel times of the second echoes indicates that the deepest point actually lies near the centre of this masked zone at about 5,900 fathoms but with a rather large uncertainty. Thus the Tonga Trench may be deeper than even the Marianas Trench; measurements with a narrow beam echo-sounder are needed to resolve the question. A detailed discussion will be published shortly by one of us in the *Journal of Deep Sea Research*.

It is remarkable that all three of the greatest measured ocean depths, though recorded from widely separated areas, lie within 200 fathoms of each other in the V-shaped portions of deep trenches. This close agreement may reflect both the nature of the trench-producing forces and the strength of the earth's crust.

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Roger Revelle

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[1] Hess, H. H., and Buell, jun., M. W., *Trans. Amer. Geophys. Union* **31**, 401 (1950).
[2] Carruthers, J. N., and Lawford, A. L., *Nature*, **169**, 601 (1952).
[3] Gaskell, T. F., Swallow, J. C., and Ritchie, G. S., *Deep Sea Research*, **1**, 60 (1953).
[4] This term is used in accordance with the rules of nomenclature stated by Wiseman, J. D. H., and Ovey, C. D., *Deep Sea Research*, **1**, 11 (1953).
[5] Kuwahara, S., *Hydrographic Rev.*, **16**, No. 2, 127 (1929).
[6] Wüst, G., *Die Erde, Z. Gesel. Erdkunde, Berlin*, **3/4**, 203 (1950/51).

Bursting of Air Bubbles at the Surface of Sea Water

In recent communications, Woodcock *et al.*[1] and Knelman *et al.*[2] have described experiments in which they have studied the fragments produced by the bursting of bubbles at an air–water interface. Both groups of workers have obtained high-speed photographs of the later stages of bubble bursting which show a small jet of water being projected vertically into the air and breaking up to form a few drops. The main differences between the results of the two sets of experiments lie in the fact that whereas Knelman *et al.* used bubbles of a few millimetres diameter, Woodcock *et al.* used much smaller ones (0·2–0·02 cm. diameter) which produced much finer jets and correspondingly smaller drops. But, besides the drops produced by the jet, Knelman *et al.* also found some much smaller droplets which, they suggested, may have been produced by break-up of the bubble film. The American workers[3] report that the formation of such a group of smaller droplets was not associated with the bursting of their very small bubbles and suggest that this second mechanism occurs only in larger bubbles. It may be, of course, that the droplets produced by the disruption of very thin films are too small to be detected by normal methods, particularly as they will evaporate very quickly.

Some recent experiments I have carried out appear to throw some light on the problem. The bursting of bubbles of 0·3–4·3 mm. diameter at the surface of sea water has been studied. The mean diameter of the drops produced by a breaking jet was roughly 15 per cent of the diameter of the parent bubble. In addition to these large drops projected vertically into the air, a second group of droplets having diameters between 5 μ and 30 μ, and containing between 2×10^{-12} gm. and 5×10^{-10} gm. of salt were found several centimetres from the bursting bubble and very close to the water surface, which suggested that they were ejected at a low angle to the horizon. The numbers of these droplets were always small, a bubble of 2 mm. diameter producing, on average, only about one droplet in this size range. Similar results have been obtained by Knelman *et al.* and will soon be published.

To determine whether the disruption of the bubble film produces much larger numbers of particles too small to be detected by conventional methods, the bursting of bubbles has been studied in a cloud chamber. Clean filtered air is passed through identical

jets into two chambers, one containing sea water and the other distilled water. After an equal number of bubbles has burst in each chamber an expansion is made; a dense cloud of tiny droplets is then observed in the space above the sea water but not above the distilled water. It appears that the bursting bubbles produce very small salt particles which can act afterwards as condensation nuclei during the expansion.

Bubbles of 3-mm. diameter produce 100–200 of these nuclei, the majority of which are estimated to have salt contents between 10^{-15} gm. and 2×10^{-14} gm., while smaller bubbles of only 0·5 mm. diameter burst much more violently and produce comparable numbers of nuclei. It seems entirely reasonable that these nuclei, representing the residues of droplets with diameters 0·4–1·0 μ, should be produced by the break-up of the bubble film into filaments in the manner suggested by Knelman *et al.*

The cloud chamber experiments suggest that if foam patches are largely composed of bubbles greater than 0·5 mm. diameter, disintegration of the bubble films will be a much more important mechanism for the production of salt nuclei than break-up of the jets, since the latter produce only small numbers of relatively large drops which will quickly fall back into the sea.

B. J. Mason

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London, S.W.7. Aug. 1.

[1] Woodcock, A. H., Kientzler, C. F., Arons, A. B., and Blanchard, D. C., *Nature*, **172**, 1145 (1953).
[2] Knelman, F., Dombrowski, N., and Newitt, D. M., *Nature*, **173**, 261 (1954).
[3] Blanchard, D. C., *Nature*, **173**, 1048 (1954).

Linguistic Studies in Polynesia

In an article entitled "Comparative Philology and Polynesian Studies", published in *Nature* of October 10, 1953, Prof. Alan S. C. Ross points to the need of a scientific study of the Polynesian family of languages, and suggests a plan for such studies. Our purpose in commenting on Prof. Ross's article is two-fold: (1) to show that structural linguistics, the recent development of which Prof. Ross disparages, may be of help in Polynesian studies; and (2) to express a somewhat different picture of the present status of Polynesian and Malayo–Polynesian studies.

The development of structural linguistics in the past few decades may be considered a natural growth of a new science from preoccupation with purely technical collection of data, to an analysis of those data on a higher level of abstraction. Such a growth would seem to hold true of disciplines as diverse as astronomy, physics and grammar. Accurate amassing of detail no longer suffices. The desideratum is now analysis and synthesis of the data.

A good many languages have been studied by the new descriptive techniques, both of the 'exotic' variety and the well-known European ones. Each language, however, is approached with fresh eyes, with awareness of methods used elsewhere, but with realization that other descriptions cannot serve as exact models for the next language to be described.

Yet in his discussion of a method for Polynesian studies, Prof. Ross first suggests that Polynesian grammars be written on the model of ancient Indonesian, such as Old Javanese. He then rejects this idea, but without stating any reasons for his rejection. (A good reason is that only fragments of Old Javanese grammar are found in modern Hawaiian, for example). Then he proposes to eliminate grammars altogether, and "to relegate all that would be in them to the dictionaries". There seems to be a danger, however, that such a procedure would eliminate a unified approach and synthesis of the disparate phonetic and morphemic data into wholes.

Prof. Ross suggests that most structuralists are uninterested in comparative studies; yet Isidore Dyen of Yale University, who is probably the most productive Malayo–Polynesianist alive to-day, is both a descriptivist and a comparativist. At least two linguists (Robert A. Hall, jun., and George L. Trager) have insisted that the only acceptable comparative work is that which utilizes descriptive techniques at every stage, on both phonemic and morphological levels. Far from "despising" comparativism, most structuralists thus feel that with their techniques they can immeasurably advance comparative studies, or conversely, that comparative studies without revivification on each time-stage by structural analysis and synthesis are of doubtful validity.

As to the present status of Polynesian studies, we would point out that Polynesia itself is far more complex than Prof. Ross indicates. By our count there are at least twenty-three languages or dialects in Polynesia (not just five "principal" ones). For some of these there are fairly complete dictionaries; but for others the data are nearly non-existent, particularly for the 'outliers' in Melanesia, which are in particular need of study. Samuel H. Elbert has recently published a paper[1] that establishes a tentative system of sound shifts for twenty Polynesian languages or dialects, draws up a tentative family tree for sixteen of them, and suggests time dates for their separations from the central stock.

At the present time a joint research programme in the Oceanic field is being conducted by Yale University, the University of Hawaii, and the Bernice P. Bishop Museum. This programme, supported by a grant from the Carnegie Corporation, is directed toward understanding the processes of culture change that have been and still are operating in this island area, with particular reference to the Malayo–Polynesian-speaking peoples. Prof. Ross states in his article that "anthropologists rather naturally tend to regard linguistics as a subordinate subject". It is interesting to note that, although this programme is indeed anthropological, one of its initial, major efforts involves library and field research conducted by professional linguists with the aim of gaining a fuller knowledge of the historical relationships among the Malayo–Polynesian languages. Polynesian is an important concern in this effort.

Prof. Ross's suggestion of a New Zealand centre for the study of the comparative philology of Polynesian merits serious consideration. However, in view of the severe financial limitations under which universities supporting linguistic research are at present working, perhaps a more feasible approach is the furthering of co-operative endeavour among scholars and institutions everywhere with a current interest in the Pacific. There is much to be done in the Polynesian area, and all workers are welcome.

S. H. Elbert

University of Hawaii.

Alexander Spoehr

Bernice P. Bishop Museum,
Honolulu 17, Hawaii. May 5.

[1] Elbert, S. H., *Southwestern J. Anthrop.*, **9**, 147 (1953).

FORTHCOMING EVENTS

Sunday, September 5—Wednesday, September 8

British Association for the Advancement of Science (at Oxford).—Continuation of Annual Meeting.

Sunday, September 5

At 8 p.m.—Prof. C. A. Coulson, F.R.S.: "Science and Religion".

Monday, September 6

At 10 a.m.—Dr. C. J. Stubblefield, F.R.S.: "The Relationship of Palæontology to Stratigraphy" (Presidential Address, Section C).

At 10 a.m.—Prof. A. D. Macdonald: "The Relief of Pain" (Presidential Address, Section I).

At 8 p.m.—Dr. E. P. Bowden, F.R.S.: "Friction".

Monday, September 6—Thursday, September 9

Physical Society (at the Cavendish Laboratory, Cambridge). Conference on "The Physics of the Ionosphere".

Monday, September 6—Tuesday, September 14

Institute of Metals (in Switzerland).—Forty-sixth Annual Autumn Meeting.

Tuesday, September 7—Tuesday, September 14

British Mycological Society (centred on the University of Southampton).—Autumn Foray, 1954—New Forest, Hampshire.

Thursday, September 9—Monday, September 13

Textile Institute (at Ghent).—Conference on "Fibre Friction".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Physicist (with a good honours degree in physics, and at least two or three years research experience, and preferably some practical acquaintance with electronics), to work under the Professor of Laryngology and Otology in the field of psycho- and physio-acoustics—The Secretary, Institute of Laryngology and Otology, 330–332 Grays Inn Road, London, W.C.1 (September 10).

Scientific Officer (with a first- or second-class honours degree in physics or mathematics, and an interest in applying mathematics to practical problems), to carry out theoretical work in connexion with the design of nuclear reactors—The Establishments Officer, Atomic Energy Research Establishment, Harwell, Berks, quoting 2/103/139 (September 10).

Assistant Biochemist (with a degree or equivalent qualification in chemistry, and wishing to take up clinical biochemistry)—The Secretary, Welsh National School of Medicine, 34, Newport Road, Cardiff (September 11).

Lecturer (with teaching experience, and a special knowledge of the theory and operation of electrical machinery) in Electrical Engineering—The Secretary of University Court, The University, Glasgow (September 11).

Lecturer (graduate in medicine) in Physiology—The Assistant Registrar, The Medical School, The University, Birmingham 15 (September 17).

Assistant Sylviculturist (with a degree in forestry, and preferably with practical experience in sylvicultural research and biometry) in the Wattle Research Institute of the University of Natal, Pietermaritzburg—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (September 30).

Lecturer or Assistant Lecturer in Histology and Embryology in the Department of Veterinary Anatomy—The Secretary, Royal Veterinary College and Hospital, Royal College Street, London, N.W.1 (September 30).

Lecturer or Junior Lecturer in Sociology at Rhodes University, Grahamstown, South Africa—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (South Africa, September 30).

Lecturer (with a degree in electrical engineering, preferably with honours, and a knowledge of the theory of automatic control) in Electrical Engineering, at the New South Wales University of Technology, Sydney—The Agent-General for New South Wales, 56–57 Strand, London, W.C.2 (October 15).

Chair of Mechanical Engineering in the New South Wales University of Technology, Sydney—The Agent-General for New South Wales, 56–57 Strand, London, W.C.2.

Chemist (with a first- or second-class honours degree in chemistry, and preferably with some experience of plant biochemistry), to work on nutritional disorders of glasshouse crops—The Secretary, Experimental and Research Station, Cheshunt, Herts.

Chemist (with an honours degree of a British university in chemistry, and/or Associate or Fellow of the R.I.C., and with three years postgraduate experience) in the Medical Department, Hong Kong, to assist the Government Chemist in analytical and consulting work concerned with public health; control of narcotic drugs; strategic materials; dangerous cargoes; commercial analytical work; toxicology, etc.—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting BCD/117/51/108.

Microbiologist (with biochemical training) for research on the anaerobic fermentation of cellulose-rich materials; a Biochemist (with training in plant physiology and microbiology) for research on the biochemistry of nitrogen fixation in nodules on leguminous plants; and a Microbiologist (preferably with mycological training), for research on the effects of antiseptics on the soil microflora—The Secretary, Rothamsted Experimental Station, Harpenden, Herts.

Mining Geologist (with a B.Sc. degree with honours in mining geology) in the Colonial Geological Survey Service, Sierra Leone, the duties which include search for new mineral deposits, mapping, petrology and mineralogy of known mineral deposits, geological mapping, and geophysical prospecting by resistivity and magnetometry—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting BCD.105/15/02.

Physical Chemist (with a good honours degree, and preferably with research experience) in the Colloid Chemistry Section—The Director of Research, British Rubber Producers' Research Association, 48 Tewin Road, Welwyn Garden City, Herts.

Physicist (Ph.D. or equivalent status, with experience in vacuum technique), for development and control of freeze-drying of biological subjects—The Director, Wellcome Research Laboratories, Langley Court, Beckenham, Kent.

Research Assistant (graduate in physics or electrical engineering, and interested in the technical problems of nuclear particle accelerations) in Physics—The Registrar, The University, Birmingham 15.

Research Physicists and Electronic Engineers (with first-class qualifications and experience), with the European Council for Nuclear Research, Geneva, to assist in the design and construction of high-energy accelerating machines for nuclear research—The Secretary, Ministry of Labour and National Service, Almack House, 26 King Street, London, S.W.1, quoting AS.12/CERN.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Forestry Commission. Thirty-Fourth Annual Report of the Forestry Commissioners for the year ended September 30th, 1953. Pp. 84. (London: H.M. Stationery Office, 1954.) 3s. net. [17

Association of Principals of Technical Institutions and Association of Technical Institutions. Report on the Development of Higher Technological Education. (Summer Meeting—Southport, 10th–12th June, 1954.) Pp. 7. (London: Association of Technical Institutions. (The Polytechnic, London, W.1), 1954.) [57

Calendar Reform and the Seven-Day Week: a Clarification. By Elisabeth Achelis, James Avery Joyce and Daniel Sher. Pp. 30. (London: World Calendar Association, 1954.) 1s. [57

Ordnance Survey. Professional Papers. New Series No. 19: The Geodimeter Measurement of the Ridge Way and Caithness Base, 1953. By Major I. C. C. Mackenzie, R.E. Pp. iii+48 (14 plates). (London: H.M. Stationery Office, 1954.) 5s. net. [57

Institution of Gas Engineers. Publication No. 440: 91st Annual Report and Accounts. Pp. 42. Publication No. 441: Presidential Address. By John T. Haynes. (91st Annual General Meeting, Bournemouth, 31st May to 3rd June, 1954.) Pp. 9. Publication No. 442: The Organization of the Gas Industry in the South West. By C. H. Chester. Pp. 55. Publication No. 443: Civil Defence and the Gas Industry. By W. N. Marshall. Pp. 30. Publication No. 444: Natural Gas and the Italian Gas Industry. By Dott. Ing. A. Böhn. Pp. 15. Publication No. 445: Centralized Control of a Gas Grid. By F. G. Symon. Pp. 25. Publication No. 446: The Appreciation of Factors Affecting Cost in the Gas Industry. By Dr. J. M. S. Rist. Pp. 23. Publication No. 447: Human Relations in the Gas Industry. By Henry Lesser. Pp. 20. Publication No. 448: Official Programme, 91st Annual General Meeting, Bournemouth, 31st May to 3rd June, 1954. Pp. 15. (London: Institution of Gas Engineers, 1954.) [57

Other Countries

Comptes Rendus des travaux du Laboratoire Carlsberg. Série Physiologique. Vol. 25, No. 10: Some Studies on the Genus *Saccharomycodes* Hansen. By Asse Hjort. Pp. 259–284+3 plates. 2 kronor, 50 øre. Série Chimique. Vol. 29, No. 2: Studies on Pinocytosis in the Amoeba *Chaos Chaos*. Pp. 7–26+1 plate. 1 kronor, 75 øre. Vol. 29, Nos. 3–4: A Method for the Production of the Plakalbumin-Forming Proteinase from *Bacillus Subtilis*. By A. V. Güntelberg. Purification of the Proteolytic Enzyme from *Bacillus Subtilis*. By A. V. Güntelberg and M. Ottesen. Pp. 27–48. 1 kronor. 75 øre. Vol. 29, No. 5: Partition Chromatography of the A and B Chains of Insulin. By William Anderson. Pp. 49–56. 65 øre. (Copenhague: En Commission Chez H. Hagerup, 1954.) [57

Bulletin of the American Museum of Natural History. Vol. 104, Article 1: Bees of Panama. By Charles D. Michener. Pp. 1–176. 3 dollars. Vol. 104, Article 2: A Revision of the Genus *Torsus* Morrison (Lepidoptera, Geometridae). By Frederick H. Rindge. Pp. 177–236. 1 dollar. (New York: American Museum of Natural History, 1954.) [57

Scientific Research of Mellon Institute, 1953–54. (Annual Report Series, No. 41.) Pp. iv+56. (Pittsburgh: Mellon Institute of Industrial Research, 1954.) [57

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